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AN

ESSAY

ON THE

STRUCTURE AND FORMATION

OF THE

Teeth in Man and Various Animals.

BY ROBERT BLAKE, M. D.

REVISED AND CORRECTED WITH NOTES,

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Surgeon Genl's Office
25769
BALTIMORE:

PUBLISHED BY THE AMERICAN SOCIETY OF DENTAL SURGEONS.

JOHN W. WOODS, PRINTER.

1848.

AMERICAN SCIENCE SERIES

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Earth in Man and Marine Animals

BY ROBERT BLAKE, M. D.

LECTURE AND CHAIRMAN OF THE

OF THE CORPUS OF THE

UNIVERSITY OF CHICAGO, CHICAGO, ILL.

BALTIMORE

PUBLISHED BY THE AMERICAN SOCIETY OF SCIENTIFIC WRITERS
JOHN W. WOOD, EDITOR

1882

TO
BRYAN HIGGINS, M. D.

WHOSE EFFORTS IN THE
IMPROVEMENT OF NATURAL KNOWLEDGE,

HAVE

"FOR THE ADVANTAGE OF MANKIND,"

BEEN ASSIDUOUSLY AND SUCCESSFULLY EXERTED,

THIS ESSAY

IS GRATEFULLY AND AFFECTIONATELY

INSCRIBED BY

ROBERT BLAKE.

PREFACE

TO THE AMERICAN EDITION.

WITHIN the half century that has intervened since the publication of the inaugural dissertation of Dr. Blake, great and important truths have been ascertained in odontological science; still, the work of Dr. Blake stands high in the estimation of the profession, and as a work of reference invaluable, and few services could be rendered the profession more acceptable than a republication of the work.

With a consciousness of the above, the editor has consented to lend his assistance in revising, correcting and adding such explanatory notes as shall be deemed necessary in guarding against the establishing views contrary to recent ascertained facts. It would appear almost superfluous to observe, that the additions are not made with a view to pluck one leaf from the laurels which crown the brow of the author, for the editor as well as the profession feel too thankful for what has already been done to permit any such ungrateful abstractions of merit.

It is due to myself to state that the position of editor is assumed with onerous duties pressing their demands, and the additions will be compelled to be made in haste, and during such moments of leisure as may occur, and which by the young professional man are highly valued.

CYRENEUS O. CONE.

N. E. Corner Charles and Lexington sts. }
BALTIMORE, January 1, 1848. }

ADVERTISEMENT.

AGREEABLY to the laws of the University of Edinburgh, my thesis was presented to one of its professors in June, 1798, three months previous to my graduation.

The favorable reception my thesis met with, from some of the highest literary characters, induced me, on my return to this country, to promise an immediate translation; but anxious to see some preparations in London, references to which I thought would more clearly elucidate some principles I wished fully to establish, and not having it in my power to visit that capital until September, 1799, I thought better to defer its publication. However, the additions made, I trust, will, in some measure, apologise for its delay, and I hope it will now be found worthy the attention and indulgence of the public. In order to render this essay more generally understood, the quotations are translated as literally as possible, and although the original plan has been followed with little deviation, yet such alterations have been occasionally made as it appeared would be either useful or interesting.

ADVERTISEMENT.

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INTRODUCTION.

To man, as his exclusive privilege, has the investigation of her works been allotted by nature. From this pursuit does he derive the truest source of mental happiness: with admiration he beholds, with rapture he traces her, through her mysterious paths, at once delighted and astonished at those admirable contrivances, by which she conducts her various operations. Nor has this spirit of inquiry been limited to any age or people; slow yet certain in its progress, it has with unerring pace pursued its grand design. Hence innumerable advantages have, from time to time, accrued to society: to this principle has the cultivation of philosophy in general been indebted; and thus has that division of it, more immediately connected with the preservation of our own species, been rescued from the hands of empirics, to be placed high amongst the other branches of science.

I need scarcely observe that this great progress in medicine, has been, as in other sciences, owing to an accurate and sedulous attention to its principles; I mean anatomy and chemistry, as well as the laws of the animal economy. Yet numerous and rapid as have been the different improvements and discoveries made in the various branches of these sciences since the year 1700, little has been done in that department, which I have selected for the subject of the following essay, since the year 1563, when Eustachius published the first edition of his *Opusculum de Dentibus*. From that period, however, diseases of the teeth began to attract attention, and a few valuable works were written on that subject.

Amongst the first of these is a work published by Urbain

Hemard,* an ingenious French surgeon. Some others appeared nearly about the same time, as also in the course of the sixteenth century, to notice which, the limits of this essay would scarcely allow me; indeed I consider any reference to them at present unnecessary. About the year 1700, the necessity of some artificial mode of preserving the teeth attracted particular attention in Paris, and a few surgeons there, began to confine their operations to diseases of the mouth and teeth alone; from which period may be dated the commencement of useful knowledge in that branch, founded on experience. Of those works published on the continent the best is that by *Fauchard*.† Though a very ingenious and useful essay appeared afterwards on the same subject, by *Bourdet*,‡ this I had not an opportunity of perusing until some time after my thesis had been printed. The only treatise of consequence which has appeared in our language, is by the celebrated Mr. John Hunter, under the title of the *Natural History of the Human Teeth*.§ This contains some ingenious and valuable observations; but as many of them were collected from dentists of his acquaintance, and as Mr. Hunter did not confine his operations to that part of medical surgery in question, I should be less inclined to place implicit confidence in his opinions, respecting a branch, which, though limited, yet requires the most minute attention, and unremitting investigation.

On comparing these works with those of anatomists in general, I found innumerable points by no means cleared up, and by the advice of the celebrated Dr. Rutherford of Edinburgh, I applied closely, some years to this branch of anatomy, with a view to ascertain the structure and formation of the teeth. During these researches, many circumstances occurred, which, as far as I have been able to learn, had been hitherto altogether overlooked; and which seemed to me of the greatest impor-

* *Recherche de la vraie Anatomie des dents, nature et proprieté d'icelles, avec les maladies qui leur adviennent.* Published at Lyons, 1582.

† *Le Chirurgien Dentiste*, published at Paris about the year 1740.

‡ *De l'art du Dentiste*, Paris, 1757.

§ Published at London, 1771.

tance in the management of the teeth and gums, particularly those of children. I therefore thought it more advisable, at once to submit my ideas on this subject, to the consideration of the public, even with all their imperfections, than delay them to a future period. It is my intention, however, to treat of the diseases incident to the teeth and gums, more fully hereafter.

To be more readily understood, I have annexed plates, representing those preparations which I thought most essential; some of them were not recent, owing to the very great difficulty of procuring subjects which had died, at the precise period when the gradations would have been particularly conspicuous; of course the engravings from these cannot be expected to convey as perfect ideas of them, as could have been wished. Some of the engravings are larger, others somewhat smaller than the preparations they represent; this necessarily happens where compasses cannot be used; for the most part, however, they are accurate.*

As I intend, in a great measure, to confine my observations in the following essay to the teeth and gums, I must refer those who wish for a more particular description of the jaws, to works written on *Osteogeny* and *Osteology*.† It is, however, necessary to mention, that in general about two months after conception, ossification commences in the membranes and cartilages of the jaws. For example, the under jaw is at first composed of two pieces connected by ligaments at the middle of the chin. The base of each piece, is the part which begins to ossify; then the sides, which are in general, called alveolar processes, undergo a progressive change of consistence. They are formed of two laminae, an external one next the cheek, and an internal one next the tongue; so that a groove is formed by these processes, in which are contained the vessels, nerves, and several little soft pulpy substances, all of which are separated from each other by proper membranes. As ossification ad-

* In this edition it is not deemed necessary that the engraving, accompanying the original work be introduced for the explanation of the text.—*Ed.*

† Albinus, *ossium fœtus humani*; Munro, Nesbitt, Havre, &c.

vances, bony fibres shoot across from contrary sides of the processes, forming an enclosure round each pulp, the circumference of which is commonly called a socket, and as some teeth have several roots, a distinct socket is formed around each root.

In children a certain number of teeth are formed, which being intended to last for only a limited time, they then gradually loosen, fall out, and are succeeded by as many new ones, some of them fall about the sixth or seventh year, while others remain until the tenth, twelfth, or even the fourteenth year. The necessity for shedding the infantile teeth will appear sufficiently obvious, when we consider that larger teeth in general are necessary for the purposes of an adult, than for those of a child ; so that nature found it an easier process to form new ones, than extend or enlarge the old, which indeed from their particular structure could not be effected. When the parts have arrived at such degree of extent, as to allow teeth to be formed sufficiently large, the teeth so formed are never shed ; such are the adult or permanent grinders. It is to be understood, however, that these observations relate to man, or quadrupeds whose teeth resemble those of man ; for in other animals a remarkable difference occurs, as shall afterwards be particularly noticed.

The annual change of the shell of the lobster, and many other species of shell fish, may be explained on similar principles ; for their shells are formed nearly in like manner with the teeth, and of course they cannot extend ; so that when the body of the animal is about to increase, the shell opens in a particular place, allows the soft parts to get out, and in some short time after, a new shell is formed over them.

The first teeth according to the celebrated Albinus, I have called deciduous ; but will now make use of the word temporary in preference, that being the term in most general use ; these teeth are twenty in number, and are divided by Mr. Hunter into three classes, called, *incisores*, *cuspidati* and *molars*, or grinders. There are in each jaw, four *incisores*, two *cuspidati*, or those commonly called eye-teeth, and four *grinders*.

The teeth which succeed them, and the entire of the adult set, I have called immutable, though Albinus confines this term to

the grinders of the adult, which, as I said before are not shed ; the word permanent, however, I intend to substitute for it. These teeth are thirty-two in number, and are properly divided by Mr. Hunter into four classes ; in each jaw, there are four *incisores*, two *cuspidati*, four *bicuspides*, or the two at each side immediately next the *cuspidati*, and six *grinders*.

As almost every name which has been hitherto made use of to express that hard and polished substance, with which the body of a tooth is covered externally, supposes it to be of a vitreous nature, than which nothing can be more erroneous ; I have taken the liberty to call it the *cortex striatus*, as such an appellation seems to coincide more with the nature of it.

It is scarcely necessary to observe, that each tooth is divided into three portions ; the body or that part which appears above the gum ; the neck or termination of the *cortex striatus* on the bony part ; and the root.

ESSAY.

CHAPTER I.

RUDIMENTS OF THE TEMPORARY TEETH.

ON examining the jaws of a fœtus, about the fourth month after conception, I observed the rudiments of vascular membranes of twelve teeth in each jaw ; scil. those of all the temporary teeth, and also those of the anterior permanent grinders. These membranes or sacs were even at this period sufficiently apparent, and so intimately connected with the internal part of the gum, that they seemed derived from it, and came away with it, when torn from the groove in the jaw, leaving behind the vessels, nerves, &c. with which they had been in contact. At this period there was scarcely any appearance of the bony fibres, shooting across from the alveolar processes, to form sockets ; except those intended for the incisores.*

* The more recent researches of Mr. Goodsir, which are published in the Edinburgh Medical and Surgical Journal, for January, 1839 ; was commenced at a much earlier period of fetal existence than the researches of Dr. Blake.

Mr. Goodsir's investigation was commenced on an embryo at six weeks after conception, measuring in length seven and a half lines, and weighing fifteen grains.

At the above mentioned period, to the eye of Mr. Goodsir, the jaws presented two semicircles folded around its circumference, the most external represented the lip, the internal the palate ; between these was a groove, lined by the mucous membrane of the mouth. A little later in the period of fetal existence, a ridge is developed from the bottom of the groove, which looks outward, this is the rudiment of the external alveo-

The vessels which enter the lower part of these sacs, deposit in them a substance, exactly similar to jelly in consistence and transparency ; upon this the bony part of the tooth is formed ; it becomes very vascular, and assumes nearly the shape and size which the upper part of the tooth is to have, after the ossification of it has commenced. This substance is commonly called the pulp ; on some of them I observed elastic bony shells already formed in the *fœtus* I have just mentioned.

In a *fœtus* between the eighth and ninth month, ossification had commenced on all the pulps, and at one point, even on the pulp of each of the anterior permanent grinders. The rudiments were all of them nearly separated by bony partitions, except those of the posterior temporary and anterior permanent grinders, which were still contained in the same socket.

In children at birth, I have generally found the shells some-

lus. At the seventh week, the germ of the first molar makes its appearance, in the aspect of a "simple free granular papilla" of the mucous membrane, which, before, was said to cover the floor of the groove. At the eighth week, the papilla of the canine or *cuspidatus* tooth makes its appearance, and, at the ninth week, the papillæ of the four incisores are seen ; the two central preceding the two lateral a little, and at the tenth week, all of the papillæ of the whole of the deciduous teeth of the upper jaw are quite distinct. The germs of the teeth in the inferior jaw are a little more tardy in their appearance. At the seventh week, the papilla of the first inferior molar, appears as a slight bulge on the mucous membrane. At about the eighth week, the primitive or dental groove for the reception of the germs of the deciduous teeth, becomes contracted before and behind, and lamina of mucous membrane are developed around other papillæ, which increase in growth, and enclose the papillæ in follicles with open mouths. The follicle of the first molar is completed at the tenth week, and soon after which follows the completion of the follicle of the canine tooth. The follicles of the incisores are completed during the eleventh and twelfth weeks, and during the thirteenth week the follicle of the posterior molar is completed.

At about the thirteenth week, the papillæ assume the shape of the teeth which they are to represent. The follicles have developed from their mouth, small membranous processes which act as an operculum, in closing the follicles at their mouths. At or near this period the researches of Dr. Blake commenced.

what more advanced, and all the points of ossification nearly united on the pulps of the temporary grinders.

The sacs or membranes which surround the shells, are thickest and most dense next the gum; but become by degrees softer and more gelatinous towards the lower part. They can be easily separated into two lamellæ, the external of which is spongy and full of vessels. The internal one is more tender and delicate, and seems to contain no vessels capable of conveying red blood, at least I could not discover any such, even though assisted by a very subtile injection. These experiments I have repeatedly made, on the membranes of premature calves with the same success. The celebrated Mr. John Hunter, however, asserts the very reverse, for he says,* "The external is soft and spongy, without any vessels; the other is much firmer, and extremely vascular." The internal part of these sacs soon after the commencement of the bony shells, deposits on their points and sides a soft earthy matter, moistened with a mucilaginous fluid; a small quantity of which is found between the membranes and shells. This earthy matter I found, even at birth, so soft, that it could be scraped off with the nail of the finger. It may be proper to remark, that it is this soft earthy matter, which afterwards becomes the *cortex striatus*, as will be fully demonstrated in its proper place.†

* Natural History of the Human Teeth, p. 87.

† The internal lamellæ described as being more tender and delicate than what our author terms the external lamellæ of the sacs of the teeth, is the enamel pulp of Hunter, Purkinje and Raschkow, and by Goodsir, described as the "gelatinous granular substance."

In relation to this internal lamellæ, Mr. Goodsir observes, that after the follicles of the teeth close, and the papillæ assume the shape of the future tooth which they are to represent; the sacs grow more rapidly than the papillæ, "so that there speedily exists an intervening space, in which is deposited a gelatinous granular substance," which, at first, is small in quantity, but about the fifth month it is so much increased as to cover and be closely attached to the whole interior of the sacs, except for a small space of equal breadth around the base of the papilla, which retains its original appearance and complexion of the inner membrane of the folli-

CHAPTER II.

OF THE PULP, AND FORMATION OF THE BONY PART OF A TOOTH.

THE pulp seems intended for a purpose similar to that of the cartilaginous matter of the other bones, though the process of its ossification is conducted in a different manner. A tooth is formed from without inwards, the part first formed being the outermost layer, which is as large and probably as perfect at first, as at any subsequent period of life. I allude here to that part only of the outermost layer, on which the fibres of the cortex striatus are afterwards to be arranged.

Ossification commences on the highest or most prominent point of what is afterwards to be the cutting edge or grinding surface of the tooth; as also, on as many points, as there are eminences on the pulp. The bony matter being first deposited on these points, it necessarily becomes hollowed towards the pulp, and gradually augmenting, at length forms over it small elastic shells.

On the incisores and cuspidati, whose formation is more simple than that of the others, there is in general only one shell formed, but on the grinders several of them appear. On the anterior or small grinders, there are four shells formed, sometimes, however, but two. On the posterior or large grinders there are, in general, five shells, of which, in the under jaw, three are placed externally or next the cheek, and two internally. In the upper jaw, they are so situated, that their eminences are adapted to the hollows of the opposite teeth in the under jaw. As ossification advances, the bases of these shells come in contact, and at length unite, so as to form one shell, after which, ossification proceeds for some time, as in the incisores and cuspidati, gradually extending over the greater part of the pulp;

cle. This granular matter does not adhere to the surface of the pulp, although in close connection with the same, presenting corresponding eminences and depressions to such as are presented by the pulp.—*Ed.*

and when so far advanced as to form the body of the tooth, it begins to contract from without, thus shaping the neck, from which the root or roots are to commence.

As the bone of the tooth increases in thickness, the pulp is proportionably diminished, and seems as it were converted into bone,* its connection, however, with the bony part is very slight, except at its extreme elastic edge, so that when the membrane surrounding the tooth is cut open, the shell can be taken from off the pulp, without any apparent violence; indeed, without altering the shape of the pulp, or scarcely its connection with the vessels. When the shell is removed, the pulp appears covered with a very delicate membrane, on which the vessels form a net-work. This seems to be a propagation of the periosteum which enters the canal of the jaw, along with the vessels, and probably from whence are derived the bony lamellæ of which a tooth consists. Though this membrane is so slightly connected with the internal part of the shell, I cannot think Mr. Hunter's assertion warrantable, when he says, "nor are there any vessels going from the one to the other."† He might as well have denied the existence of vessels in the crystalline lens, as it more readily slips out of its capsule, than this pulp from its shell.‡

As the pulp has originally no process answering to the root or roots, it has been supposed that it is lengthened, or squeezed

* Mr. Nasmyth's recent researches would confirm Dr. Blake's supposition that the pulp was converted into bone by the deposition of ossific matter in its regularly arranged and connected cells. He says, "it is quite evident that these cells, whilst receiving a supply of earthy matter during the process of transition, must remain in connection with, and, indeed, continue to form part of the pulp.—*Ed.*"

† *Natural History of the Teeth*, p. 89.

‡ As proof of the correctness of Dr. Blake on this point, Mr. Nasmyth in his *Memoirs on the Development and Structure of the Teeth*, observes in relation to one of his plates illustrating the formation of ivory, "this drawing is an exact copy of the preparation, in which, as is seen the blood-vessels have been ruptured in two places in separating the ivory from the pulp, owing to the close connection between the reticular surface and the ivory already formed."—*Ed.*

out so as to form them, according as the cavity in the body of the tooth is filled up by the ossification.* I have already mentioned that the pulp at first assumes little more than the size of the upper part of the body of the tooth, which is to be afterwards formed upon it; but it is deposited and extends in proportion as ossification advances. It is the pulp and its vessels which give a determinate shape and size to the body of the tooth, and it will in its proper place be shown, that its processes determine the shape and size of the roots. How is it possible that the simply filling up the cavity in the shell of a grinder, could occasion the pulp to lengthen out into two, three, and sometimes four roots?

Of those teeth which are to have but one root, the pulp increases in length as I have described, becoming more and more contracted towards the point; and as ossification advances, the bone forms on it a kind of conical tube. But, in those teeth which are to have more than one root, a beautiful process is carried on. In the grinders of the lower jaw, which in general have but two roots, the pulp is divided into so many processes, a little below the neck; at this period, there is but one general opening in the shell, from the opposite sides of the edge of which, osseous fibres or little bars shoot across, through the division of the pulp; these meet and unite in the middle, and so divide the cavity of the shell into two openings, forming over it a little arch. In the grinders of the upper jaw, which have in general three roots, the pulp is divided into as many processes, and the osseous bars shoot through them, from as many different points in the margin of the shell, and uniting in the middle divide the cavity into three openings, two of which are placed externally, and one internally. Sometimes an osseous point is deposited in the centre of these processes, and fibres shooting across from the margin of the shell join it, which answers the same purpose.† From these openings, the processes of the pulp commonly become more and more divergent, and ossification extending on them forms a conical or flattened tube

* Nat. Hist. of the Teeth, p. 90.

† Albin. Acad. Annot. lib. ii, p. 17.

on each, as in teeth which have but single roots. Sometimes the pulp is divided at the neck only into two processes; ossification goes on for sometime as usual, but one or both of these become divided again, and so three or four roots are formed. I have met a few of the permanent grinders, in which the pulp did not divide into processes, so that only one root was formed. The pulp continues to advance faster than the ossification, until each process has acquired its proper length and shape; then the pulp, except where the vessels and nerves enter, becomes entirely surrounded with bone.*

Mr. Hunter mentions,† “By the observations which I have made in unravelling the texture of the teeth, when softened by an acid, and from observing the disposition of the red parts in the tooth of growing animals, interruptedly fed with madder, I find that the bony part of a tooth is formed of lamellæ, placed one within another. The outer lamella is the first formed, and is the shortest: the more internal lamellæ lengthen gradually towards the fang, by which means in proportion as the tooth grows longer, its cavity grows smaller, and its sides grow thicker.” Now from my observations, the fact is directly the reverse; the outer lamella, which is the first formed is longest, the internal lamellæ become shorter and shorter, and the last formed is the shortest.‡ Hence in teeth with single roots, the cavity of the shell is not only diminished, but it recedes from

* Mr. Goodsir mentions still earlier indications of the formation of the fangs of the superior molares, than the period marked by the division of the pulp by ossific fibres. He tells us, that soon after the follicles have become closed, and the pulp has assumed the shape of the future teeth of which they are the germs, the superior molar pulps “begin to be perforated also by three canals, which, proceeding from the surface to their centres, gradually divide their primary base into three secondary bases, which become developed into the fangs of the future teeth.”—*Ed.*

† *Natural History of the Teeth*, p. 92.

‡ In relation to this question, Mr. Nasmyth says, speaking of the structural formation of a tooth “that it will be observed to present a laminated, concentric structure, being apparently composed of layers gradually increasing in size from the centre to the circumference.”—*Ed.*

the apex or cutting edge of the tooth, whilst a conical tube is left for the admission of vessels, &c. the base of which ending in the body of the tooth, has its opening or point nearly in the extremity of the root. The lamellæ of a grinder, are distributed more irregularly than those of any other tooth, on account of the protuberances of its pulp. As its external lamellæ advances very slowly, a great number of the internal ones are advancing, at the time that the external lamellæ has got so far as to form the neck. So that the cavity of a grinder recedes from the grinding surface, more rapidly than that of any other tooth. After the roots commence, the cavity is soon diminished, the ossification going on at the same time at both the upper and under parts of it. As many conical or flattened tubes are left leading to the cavity as there are roots; and as many hollows or depressions in the superior part of the cavity, as there are protuberances on the grinding surface. The pulp, though very much diminished, still retains nearly its original shape.

It may appear singular, that the pulp should not be entirely obliterated, and the ossification completed, without any remaining cavity; it however affords this advantage, that the vessels and nerves distributed on the soft membrane of the pulp may have free action and not be compressed; by which means the internal bony part of the tooth may be more readily nourished.

It is asserted by a celebrated anatomist, that he has constantly found two holes near the point of each root, for the admission of vessels, not only of the incisores and cuspidati, but also of those of the grinders; which he supposes to have been established by nature, in order to guard against accident, lest if one vessel were injured or destroyed, the other might continue to nourish the pulp. I confess I was never so fortunate as to meet a single instance of this kind, even in the incisores of large animals; except in such cases as Eustachius mentions, where he says, (speaking of the roots of the permanent grinders,) "Many of those (sc. roots,) being flattened, their sides thus approach; so that, instead of a circular opening, an oblong one is formed, the central points of whose sides coming into contact, leave at

either end a small canal.”* In such roots, however, I have frequently found but one opening externally, for the admission of vessels, &c. but after their entrance, each divided into two branches. Haver mentions,† that in a tooth which had but one root, he met two passages, one at each side. This root must have been formed in the manner Eustachius describes. I have seen a few of the permanent incisores with almost two distinct roots, the cuspidati with two, sometimes with three roots, and the grinders with four and even five roots, and of course as many openings as roots.

CHAPTER III.

OF THE GRADUAL WASTE OF THE MEMBRANE WHICH SURROUNDS THE BODY OF A TOOTH, AND THE PERIOD AT WHICH THE TEMPORARY TEETH IN GENERAL APPEAR.

The membrane which deposits the earthy matter of the *cortex striatus*, does not adhere to, but loosely surrounds the body of the tooth; but as soon as the neck is formed, the margin of the membrane adheres to it so firmly at that part, that it cannot be separated from it, without lacerating several vessels which pass from it to the bone. The membrane becomes much thinner at this part, and I could not separate it at any period into two lamellæ.‡

* “Sæpe enim earum multæ hanc ob causam amplam rotunditatem in latitudinem mutant, ejus duæ extremæ partes quum se mutuo occursum tangant, foramen angustum et oblongum efficitur, quod in medio fere obæreatum duos parvos canaliculos utrimque obtinet.” (*Opuscul. De Dentib.* p. 26.)

† Osteologia, p. 79.

‡ It was observed before, that the gelatinous granular substance of Goodsir, and the internal lamella of the text, is the enamel pulp of Hunter and Purkinje, and called by Raschkow, sometimes, the adamantine organ.

As before remarked, this gelatinous granular substance, or adamantine

As ossification advances on the root or roots, the body of

organ, is situated between the follicle and tooth-pulp, to the latter of which it "is closely applied, but does not adhere to the surface of the pulp," and while the last named organ is in its first stage of growth, "forms nearly a globular nucleus, of which the extreme appears in some slight degree to bulge out," while the internal surface presents, before its perfection and office is further advanced towards completion, the usual granular formative mass common to the early organization of other parts of the fœtus. A little later, it gradually presents more distinct granulations, and of an angular form, which are united by "filaments of cellular tissue."

This granular nucleus, which is surrounded by the investing membrane, has a small space marked between the latter, itself, and the dental germ in which is effused a peculiar fluid, closely resembling the *liquor amnii*.

As the dental germ increases in size, and advances further into the follicle, it at first makes but a slight impression on the granular nucleus of the enamel organ, but as the germ advances, the impression is rendered gradually deeper and deeper, its internal surface enclosing the dental germ on all its sides like a cap or hood, down to its base, where it is thinner, than at the apex of the germ. When in this state, it is free at all parts, and presents no nearer relation in position to the germ, or capsular membrane, than before it assumed the shape of a hood, and probably is every where surrounded by the lymph above mentioned.

When this granular mass has assumed the last mentioned shape and position, he names it the enamel pulp, and in which state, a peculiar organ is seen on its internal surface, consisting of "short, uniform fibres, placed perpendicularly, and binding the whole of the cavity intervening between the germ." This he terms the enamel membrane. According to Raschkow, (our author,) "this structure of fibres" originates in the "transformation of the pulp of the enamel," with which it is connected at first, but soon separates itself more and more, until no connection exists except by some "free filaments of cellular tissue, and thus, is connected into a true membrane." The inner surface of this membrane, he says, "consists of hexangular, nearly uniform corpuscles, visible only through a magnifying glass, towards the centre of which is a rounded eminence. These corpuscles are nothing more than the ends of short fibres," which are pressed together, and made to "assume the hexangular form." These corpuscles he describes as not only being "deposited in regular series," but correspond with the arrangement of the enamel fibres. Each of these fibres of which the membrane is composed, he supposes to be a "duct or gland, the peculiar office of which is to secrete the enamel fibres corresponding to it." As soon as the dental pulp has been covered, or ossific matter is seen upon it, the surface of each fibre above mentioned is

the tooth rises in the socket, and of course the investing membrane rises with it.*

The cortex striatus is first perfected or crystallized on the cutting edges or protuberances of the tooth, and proceeds gradually from thence to the neck where it terminates; and in proportion as the first part of the cortex striatus is crystallized, that portion of the membrane which formed it becomes thinner, less vascular, and at length, having performed the particular function for which it was destined, is totally wasted or absorbed. The gum also partakes of this tendency to waste, and the tooth gradually appears through it; part of the membrane still remains on the body of the tooth, this however is wasted, as the cortex striatus covered by it attains to perfection. So that all that portion of the membrane, which loosely surrounded the body of the tooth, is destroyed when the tooth has risen to its proper height.

De la Sonne,† and other physiologists, attempt to assign a cause, why the teeth rise and pass through the gum, by saying, that as roots are added, the bodies of the teeth are pushed or forced up through the gum, this being softer than the bottom of the sockets. But when we come to consider the appearance of the permanent teeth, we shall be fully sensible how inadequate such a theory is.‡

brought in contact with it, when they commence their function of secreting the earthy salts of which the enamel is principally composed. While this action is taking place, an "organic lymph," says our author, "seems to be secreted from the inner portion of the enamel membrane which penetrates between the fibres, and renders their entire substance soft." This, he thinks, is by means of a "chemical organic process," which afterwards unites with the earthy substance, and forms the animal basis of the enamel.—*Ed.*

* Mr. Goodsir observes, that in the formation of the fangs of the teeth, there are three cotemporaneous actions employed, viz. "the lengthening of the pulp, the deposition of tooth substance upon it, and the adhesion to the latter, of that portion of the inner surface of sac which is opposite to it."—*Ed.*

† Acad. des Scien. in 4to. L'an. 1752. Mem. p. 168.

‡ Most of the explanations of the mechanism of the eruption of the

It has been mentioned by most authors, who have written on dentition, that the membrane which surrounds the body of a tooth, is stretched, bruised, and even lacerated by the increased size of the tooth; Dr. Underwood supposes it to be strong and nervous, and adds,* “The most painful part of dentition, and that in which children are most exposed to convulsions, is usually from the teeth cutting through the periosteum, (or nervous membrane mentioned above,) that covers the teeth.”

teeth is very unsatisfactory. From what has before been said, we might infer from our author, that the tooth is erupted by the ossification of the fangs, and they meeting the floor of their alveolus, the tooth is forced through the gum by the continued and increasing deposition of ossific matter at the extremity of the fang, making the alveolus the fulcrum. This explanation would be satisfactory, was not the ossific matter deposited in a soft state, and should it, in this stage of formation, come in contact with a resisting agent, it must be reflected upon itself or the crown of the tooth. A specimen of each of the above reflections of the fang while in a soft state, demonstrating the correctness of the above, may be seen in the museum of the Baltimore College of Dental Surgery, one a molar, the other an incisor tooth.

Mr. Goodsir observes, that “I have commonly remarked, and what must have been observed by medical practitioners, that from the time that the edges of the tooth appears through the gum, it advances more rapidly than can be accounted for by the usual rate of lengthening of its fang. This advance is not invariably rapid, but may be observed in all the incisor teeth, if careful daily examination be made during a normal dentition.” Mr. Goodsir accounts for this rapid eruption, by observing in another place, that the “more adherent portion of the sac shortens more rapidly than the fang lengthens, and the inner portion becomes continuous with the mucous membrane.” This explanation of Mr. Goodsir, I think, is strong evidence in favor of the theory advanced by M. Delabarre, of the means by which a tooth is expelled from its alveolus and perfect eruption effected. He supposes the follicle to be the elevating agent. At the time when the tooth has acquired its maturity sufficiently to demand the assistance of a new agent, the follicle becomes more vascular, and is firmly attached to the neck of the tooth, and by its contraction, not only upwards, as observed by Mr. Goodsir, but in all directions that shall favor the design of nature, until the tooth is expelled, in the same manner, and by a similar expelling power that the uterus exerts over the child.

[Ed.

* Diseases of Children, vol. i. pp. 213 and 214.

Van Swieten, although he did not believe the temporary teeth had roots, says, "these rudiments of the teeth are placed in the sockets of the jaws; but the opening from each of these sockets, is covered by a thick coriaceous membrane, which must be bruised or even torn by the tooth in bursting out; so that after the tooth had burst out, the ragged edges of this membrane have been observed by the accurate *Herrissant*. These edges becoming dry, fall away spontaneously. Therefore the tooth in endeavoring to make its way out, must exert a considerable force, in order to break through this membrane."*

It appears rather strange that Van Swieten could imagine, that the temporary teeth, which in another part of his work, he observes, have no roots, could perform all these violent efforts, so as to burst through this membrane. Even Mr. Hunter says,† "when the tooth cuts the gum, this membrane or capsule is likewise perforated; *after which* it begins to waste." Others are of opinion, that the membrane being lacerated, the body of the tooth passes up through it, and that it afterwards becomes the periosteum of the root. From what I have already said, the impossibility of a tooth bursting or rising through its membrane will be easily perceived, for as it is firmly united to the neck of the tooth, it must partake of the same precise motion with the tooth, and therefore must after such motion of the tooth retain the same relative position towards it, as before. So that the disappearance of the membrane is not owing to a rupture of it, but to a wasting or absorption of it, in proportion as it has perfected the cortex striatus. This fact will be more fully explained, when we come to speak of the teeth of animals in general. I have seen the ragged edges of the membrane, appearing above

* "Hærent illa dentium germina in alveolis maxillarum; sed horum alveolorum exitus tegitur membrana satis densa coriacea, quæ ab erupturo dente pertundi debet, quinimo lacerari; ita ut, post eruptionem dentis, lacerae hujus membranæ lacinia observatæ fuerint ab accurato in similibus indagandis *Herrissant*. Exsiccatæ dein hæ lacinia sponte cadunt. Magna ergo satis vis a dente erupturo fieri debet, ut hanc membranam rumpat."

Comment. vol. xiv. p. 743.

† Hunter's Natural History of the Teeth.

the level of the gum; a similar appearance was no doubt observed by Herissant, though he attributed it to a wrong cause.*

Galen, Eustachius, and others, were of opinion, that the upper teeth appeared sooner than the under; they were fully aware, however, that they appear irregularly and at different periods. Mr. Hunter describes their appearance in the following words: "The incisores begin to cut or pass through the gums; first, generally in the lower-jaw; but the cuspidatus and molares of the fœtus, are not formed so fast as the incisores; they generally all appear nearly about the same time, viz. about the twentieth or twenty-fourth month; however, the first grinder is often more advanced within the socket than the cuspidatus, and most commonly appears before it." Chirurgical writers in general, give us a most curious jumble, respecting the appearance during dentition; and most of the strenuous advocates for cutting and hacking the gums of children, seem perfectly ignorant of the order in which the teeth appear. Dr. Underwood says,† "the two front teeth in the lower jaw are usually cut the first, and it is commonly a few weeks longer, before the corresponding ones in the upper jaw make their appearance. After which, it is frequently a considerable time before the next under teeth come out; but sometimes, though not often, six or eight are cut in a hasty succession. Children sometimes cut their teeth irregularly, or cross, as it is called, by the teeth appearing first in the upper jaw, and also at a distance, instead of being contiguous to each other: this is accounted, and with some reason, an indication of painful or difficult dentition." It is unnecessary at present, to enter more fully into the inaccuracies of these authors, or to say any thing respecting their operations, (which were all blindly, and I must say, very often rashly performed for want of anatomical knowledge of these parts,) as I intend to enlarge considerably on this subject, when I come to treat on dentition.

As ossification does not commence on all the pulps at the

* Hunter's Natural History of the Teeth.

† Diseases of Children, vol. i. p. 205.

same time, in general those on which it first commenced are soonest perfect, and of course they appear through the gum first. I have observed on examining the teeth of a number of children at birth, that the bodies of the middle incisores of both jaws were most perfect; the lateral incisores and the small grinders next; and the cuspidati and large grinders least perfect. In general, the teeth begin to appear about the sixth, seventh or eighth month after birth; but there are some exceptions to this rule; owing to the rapid progress of ossification in some children, and the slowness of it in others. There are a few instances of children at birth having one or two of the incisores already cut, and in such cases it is often necessary to remove them immediately; on the contrary, in children apparently healthy, they have not begun to appear till the first, second, or even the third year. They for the most part appear in pairs, or the two corresponding with each other, nearly at the same time. The first are the middle incisores of the under jaw, in a few weeks after the middle incisores of the upper; in a month or six weeks after, we have reason to expect the lateral incisores of the under jaw, and in a short time after those of the upper; about the twelfth or fourteenth month, the anterior or small grinders of the under jaw appear, and frequently about the same time those of the upper; about the sixteenth or twentieth month the cuspidati appear first in the lower jaw, and from the twentieth to the thirtieth month the posterior or large grinders appear in the same order: so that in general about the second or third year, the twenty temporary teeth are complete.

We must not expect, however, to find the teeth always appear in the precise order I have just now mentioned. I have frequently met with some irregularities, such as one tooth appearing a considerable time before its fellow; all the incisores of the under jaw, appearing before any of the upper; and the reverse, though very seldom, has sometimes taken place; the anterior grinders sometimes appear sooner than the lateral incisores, and the lateral incisores of the upper jaw, sooner than those of the under; I have sometimes observed the posterior grinders appear earlier than the cuspidati; but I never saw an

instance of the cuspidati appearing previous to the small grinders; sometimes three or four teeth appear nearly at the same period, but I never met an instance of the cuspidati and grinders appearing in such rapid succession as Mr. Hunter and Dr. Underwood mention. Dr. Armstrong says,* that he met two cases, where the small grinders appeared first of all; I have lately met a case similar; however by carefully examining the gums of a child, we can seldom mistake what tooth is about to appear, as the gum is frequently somewhat higher over it, than elsewhere, or it becomes so thin, that through it the shape of the tooth can be perceived.†

CHAPTER IV.

OF THE COMMENCEMENT AND FORMATION OF THE PERMANENT TEETH.

Having now fully traced the temporary teeth, from their origin to their perfect state; that I may be better understood, I shall follow nearly a similar plan, with respect to the permanent. I think it unnecessary to dwell on the ingenious hypotheses of Vesalius, Diemerbroek and others, who supposed that the bodies of the permanent teeth were produced from the old roots of the temporary. Diemerbroek adduces in support of his doctrine an instance of the stag, who changes his horns every year, or year and a half, when as he supposed from their old roots, new horns arose; but a full account and refutation of these opinions may

* Diseases of Children, p. 82.

† The eruption of the teeth are subject to great irregularity, but the usual appearance of the various classes of the temporary teeth, take place in the following order and periods: The central incisores appear from 5 to 8 months after birth. The lateral incisores from 7 to 10 months after birth. The first molares from 12 to 16 months after birth. The cuspidati from 14 to 20 months after birth. The second molares 20 to 36 months after birth.—*Ed.*

be seen in the works of the learned Albinus.* Fallopius supposed, that a certain latent seed in the jaws produced a new range of teeth.† But Eustachius explained much more clearly what takes place, than any of his predecessors, and indeed comes very near the truth, in the following words: “On dissecting a child immediately after birth, both jaws being laid open, the incisores, canini and three grinders appeared, partly gelatinous, partly bony, of no small size, and completely surrounded by their sockets; but having carefully removed the incisores and canini, I observed a very thin interstice, scarcely converted into bone, which being removed with equal care, I discovered the like number of incisores and canini, almost gelatinous and of a smaller size, which lying behind the former ones, and in their proper cavities, were placed directly opposite to one another. I confess, I did not see any trace of the grinders and jaw teeth which appear about the seventh year, and often much later.‡

Urbain Hemard, an ingenious French anatomist, makes use of nearly the same words, when treating on this subject: “He had dissected, in presence of his friends, capable of understanding this demonstration, several infants three or four days old, and others just born; he found that the incisores, the canini and some molares on each side of the jaws, were in part bony and in part mucilaginous, of middling size, and surrounded by their little cases or sockets; that after having removed the first incisores and canine teeth, he observed a bony partition; and that after having likewise removed this, he met under it, as many

* Acad. Annot. lib. ii. p. 3.

† Observat. Anatom.

‡ “Fœtu, simul atque editus est, dissecto, aperta utraque maxilla, occurrunt incisores, canini, ac tres molares, partim mucosi, partim ossei, non obscuræ magnitudinis, suisque præsepiolis undique vallati; incisoribus autem et caninis docta manu detractis, tenuissimum interstitium vix osseum factum conspicitur, quo pari diligentia amoto, obviam veniunt totidem incisores et canini pene mucosi et longe minores, qui post alios priores in propriis caveis latentes, singuli singulis e regione oppositi collocati essent; molarium et genuinorum qui circa septennium, ac longe etiam postea oriuntur, sateor me nullum vestigium vidisse.” *Opuscul de Dentib.* p. 46.

new incisores and canine teeth, as there were of the first, almost entirely mucilaginous. But as to the great molares, which at seven or eight years old, or a long time after, begin to appear through the gum, he confesses, he never found any trace or beginning of them.”*

It appears that Urbain Hemard was not acquainted with Eustachius’ work, so that he is entitled to an equal share of merit; and although the celebrated Albinus confirms the description of these parts, as related by Eustachius, yet Dr. Nesbitt thought them imaginary, and says,† “there is not at birth, as Eustachius imagined, the least appearance that I could ever find of the layer or row of teeth, by which the first is afterwards usually thrust out.” Since so great an anatomist as Dr. Nesbitt did not credit the demonstrations of Eustachius, though supported as I already mentioned by Albinus, because similar appearances did not occur to him, and finding such an imperfect description of their origin in Mr. Hunter’s work, I have dissected a great number of infants to ascertain this point, which I think of the greatest importance.

I have already mentioned, that in the youngest fœtus I examined, I observed the rudiments of the four anterior permanent grinders,‡ though I could not discover the slightest appearance of any of the other permanent teeth. But in a fœtus about the eighth month, I found the commencement of the sacs

* “Il avoit anatomisé, en présence de ses amis capables de cette démonstration, plusieurs enfans nez depuis trois ou quatre jours, et d’autres à l’instant de leur naissance, il á trouvé que les incisives, les canines, et plusieurs molaires de chaque côté des machoires, étoient en partie osseuses, et en partie mucilagineuses, de médiocre grandeur, et entourées de leurs petits éuis, ou alvéoles; qu’après avoir tiré dehors les premières dents incisives et canines, il avoit remarqué un entre deus osseux; et qu’après l’avoir pareillement ôté, il avoit rencontré dessous tout autant de nouvelles dents incisives et canines qu’il y’en avoit auparavant, presque toutes mucilagineuses. Quant aux grosses molaires, qui à sept ou huit ans, ou longtems après, commencent à sortir, il confesse n’en avoir jamais trouvé aucune trace, ni commencement.” *Fouchar d Chirurgien Dentiste*, tom. i. 37. et seq.

† Hum. Osteogeny, p. 98.

‡ Vide chap. i. p. 1.

of the incisores and cuspidati, they were not placed under the temporary teeth, nor indeed so deep in the jaw, but within side of them, that is to say, in contact with their inner surface, lying between that and the internal plate of the alveolar process, and as Albinus remarks, they were contained in the same sockets with the temporary.* In a fœtus between the eighth and ninth month, these sacs were all perfectly distinct, and the pulps of the middle incisores were tolerably advanced, they were elongated a little in the sockets, and the jaws happened to be so far advanced, that the upper surface of the sockets of the middle permanent incisores were ossified, the lower part remaining still membranous: the other sockets were less perfect, and exactly in that state as described by the accurate Eustachius. In children somewhat farther advanced, I found them nearly as Hemard mentions, and I confess I did not observe in such young subjects the slightest vestige of those which succeed the temporary grinders, or any appearance of the middle permanent ones.

Having fully shown that the assertions of Eustachius, Hemard and Albinus are true, I come now to treat more at large, of the relative situation and connection of the rudiments of the permanent with the temporary teeth, which have been hitherto unaccountably overlooked. By the writings of those great men we are informed, that a certain number of the permanent teeth began to be formed previous to birth, but we are still perfectly ignorant respecting the manner of their formation or connection; and have had nothing to guide us but imaginary conjectures, respecting the teeth which appear at a more advanced period of life. I think it unnecessary to say any thing on the hypothetical suppositions of Hippocrates, Fallopius, Eustachius, &c., but will dwell on the facts which I have discovered, and which I mentioned to a few celebrated anatomists, five years since in London.

When the rudiments of the temporary teeth are tolerably advanced, the internal part of the gum, or rather the upper part of

* *Ossium Fœtus Humani.*

each membrane destined to form one of the temporary teeth, sends off a new sac. These sacs, situated as just now described, are each at first contained in the socket of the one to which it is to succeed; and are so intimately connected with the membranes of the temporary teeth, and they cannot be separated without tearing one or both, and may be torn along with the first sacs out of the sockets.* This circumstance might

* Soon after the last period mentioned in the note to page 2, after the follicles of the temporary teeth have been closed by their opercula, a new change is observable. At or during the fourteenth week, that portion of the follicle, or mucous membrane, left above the opercula of the temporary tooth forms a small crescentic duplicature or depression behind each of the follicles of the temporary teeth, but without adhering to them. These lunated inflections of the mucous membrane are to be the cavities of reserve for all the permanent incisores, cuspidati and bicuspidi; making, what has been termed, the secondary dental groove. With the exception of the two depressions just mentioned, and a small portion situated behind the follicle of the posterior temporary molar, adhesion of every part of the groove takes place, proceeding from forwards backwards, and are thus formed into closed cavities of reserve, and gradually recede from the surface of the gum, and lie on the inner side, and almost in contact with the dental sac of the deciduous teeth. It has been stated above, that during the general closure of the dental groove, ending at the fifteenth week, the posterior part of the primitive dental groove, or that immediately behind the posterior temporary molar, is left open. At the fifteenth week, there is developed in this cavity the papilla and follicle of the first permanent molar. At the twentieth, the fundus of this follicle is converted into a sac, and the papilla into a pulp. This tooth is the first of the permanent teeth to appear, and is further characterised by being developed like the temporary teeth from the primitive dental groove, and on the same horizontal level with them. On the closing the follicle, by its opercular, of the last named tooth, there is seen a large cavity of reserve developing, and lying between the follicle and the gum. This is the posterior cavity of reserve for the development of the second and third molares.

At this period the deciduous teeth, and the sacs of the permanent, increases so much, and there not being a corresponding lengthening of the jaw, the first permanent molar is forced backward, and up into the coronoid process of the inferior jaw, and the tuberosity of the superior jaw, which situation they occupy at the eighth and ninth month of fetal existence. At the age of seven or eight months, the infant's jaws, or alveolar border, increases relatively, and the sac of the first permanent molar

have misled Dr. Nesbitt, but it is strange he did not observe the commencement of the permanent sockets, which are very evident in every subject I examined, just before or at birth. These sacs were observed by the ingenious Mr. Hunter, for he says,* “There is another pulpy substance opposite to that which we have described; it adheres to the inside of the capsula, where the gum is joined to it, and its opposite surface lies in contact with the basis of the above described pulp, and, afterwards with the new formed basis of the tooth: whatever eminences or cavities the one has, the other has the same, but reversed, so that they are moulded exactly to each other.

“In the incisores it lies in contact not with the sharper cutting edge of the pulp, or tooth, but against the hollowed inside of the tooth; and in the molares it is placed directly against their base, like a tooth of the opposite jaw. It is thinner than the other pulp, and decreases in proportion as the teeth advance. It does not seem to be very vascular. The best time for examining it is in a fœtus of seven or eight months old.

The enamel appears to be secreted from the pulp above de-

has returned from the tuberosity, or the coronoid process, to its proper position in the dental arch. The cavity of reserve, which had been elongated by the upward movement of the first permanent molar, now increases and is forced into the position in the coronoid process, or tuberosity occupied by the first permanent molar. A papilla is then formed from its base, then its superior portion is constricted, then closed, making the sac for the second permanent molar, but leaving a portion of the cavity of reserve between the superior portion of the sac and the gum which is to form the cavity of reserve for the third permanent molar. As the alveolar border is lengthened, the sac of the second molar descends into its horizontal position in the arch not far from the fourth year of age. The remaining part of the cavity of reserve mentioned as being left on the closure of the sac of the second molar, was lengthened by the ascending of the last named tooth-sac in the jaw, and about the seventh year of age forms the sac and pulp of the third permanent molar or *wisdom* tooth.

It will be seen from the above, that the pulps and sacs of both the temporary and permanent teeth have a common origin from the gastro-intestinal mucous membrane. That the permanent teeth have no connection with, and have a distinct origin from the temporary teeth.—*Ed.*

* Hunter's Nat. Hist. of the Teeth.

scribed, and perhaps from the capsula which encloses the body of the tooth. That it is from the pulp and capsula, seems evident in the horse, ass, ox, sheep, &c. therefore we have little reason to doubt of it in the human species."

Now, whether we are to understand, by the words "the pulp above described," that which he speaks of, as connected to the membrane of the first pulp, or the first pulp itself, he has left us quite at a loss to determine. At all events, with the nature, use, and formation of this second pulp he seems to be utterly unacquainted; for he first leaves us, as I before said, in doubt, whether its use be to form the cortex striatus of the first teeth, a thing next to impossible; and again he says, that in proportion as the teeth advance, it becomes thinner, which is actually the very reverse of what really happens. I need hardly add, that there are no such pulps as he describes to be found on the bases of the temporary grinders, (another inaccuracy which he has strangely fallen into,) but merely a thickening of their proper membranes.

As the sacs of the permanent teeth advance, the sockets of the temporary ones become enlarged, and little niches are formed in the internal plate of the alveolar processes answering to each socket, which are situated rather laterally, that is to say, at a greater distance from the symphysis or centre of the jaw, than the centre of each respective temporary socket. These niches do not penetrate so deep as the bottom of the temporary sockets, but increase in proportion with the size of the permanent sacs, and gradually form a distinct socket round each of them. There is, however, an opening left immediately under the gum, through which the membranes of both sets of teeth continue to be connected. The pulps of the incisores in general are so far advanced at birth, that soon after ossification commences on them. In a child about six or seven months old, I found their shells much more advanced than *a priori* I could have expected, and those of the cuspidati also had begun to ossify. The sacs of the bicuspidates which succeed the anterior grinders had appeared, yet I did not remark those which were to succeed the posterior grinders, although those of the middle permanent grinders had already commenced.

In a child about four years old, the bodies of some of the permanent teeth were very much advanced, ossification had commenced on the bicuspidæ, all the points of ossification of the middle grinders were united, and the membranes of the posterior grinders or wisdom teeth were forming. I have examined a number of children's jaws about this age, and found in general a similarity of appearance with respect to the number of teeth which were then formed, and also those which were forming. So that I may safely say, there are more teeth formed and forming at this, than any other period of life, that is, **twenty-six teeth in each jaw.**

Soon after the sacs of the permanent teeth have commenced, a very curious and beautiful process takes place, for they retain their situation at the bottom of the jaw, whilst at the same time, the temporary teeth rise and appear through the gum. The alveolar processes become enlarged, or seem to rise in proportion to the elongation of the roots of the temporary teeth; so that the permanent teeth appear now considerably beneath them, and consequently the membranes which connect the permanent with the temporary teeth, are very much elongated, and appear as nervous twigs, passing up to the gum and neck of the temporary teeth.

Albinus was perfectly acquainted with the foramina through which the connecting membranes passed, and concerning which he makes use of the following words: "The sockets in which the permanent incisores are contained, extend to the margin of the jaw; not far from it gradually becoming more contracted, and at length terminating in a small hole: the hole which belongs to the socket of the first incisor, is placed behind the first of the deciduous incisores, in the interval between it and the second: that which belongs to the second, in like manner, is placed behind the second of the deciduous incisores, in the interval between it and the canine tooth. The socket of the new canine tooth, extending only a little beyond the bottom of the socket, in which the deciduous canine tooth is contained, thence terminating in a narrow little canal; before it terminates in this canal, it gradually becomes more contracted. The sock-

ets of the new jaw teeth (the bicuspidæ) do not extend by any hole to the margin of the jaw. I find these penetrate into the bottom of the deciduous sockets, and first, indeed, near to the internal part of its roots.”* Nothing can be more accurate than this description, but it has been taken from dried jaws, otherwise he certainly would have discovered the connecting membranes.

We have seen the membrane of the posterior temporary grinder, and that of the anterior permanent grinder intimately connected together and contained in the same socket, but as the permanent grinder advances and the jaw increases in length, a process is sent backwards from the upper part of its membrane, which at first is contained in the same socket. This process gradually swells into a sac, in which is contained the pulp, whence the middle grinder is to be formed; and as ossification advances, the parts become separated by a bony partition, the connection however is still kept up. When the membrane of the middle grinder is tolerably advanced, it sends off a process in a similar manner, to form the sac of the posterior grinder or wisdom tooth.

I think it absolutely necessary to point out in this place some of the very great oversights and anatomical errors of Mr. Hunter; as his highly respected authority has frequently misled the inexperienced practitioner: He says,† “The pulp of the first adult incisor, and of the first adult molaris, begin to appear

* “Cavernulæ, quibus tomici novi continentur, ad maxillæ marginem pertinent, non longe ab eo sensim contractiores, et ad postremum in exiguum foramen desinentes: quorum quod cavernulæ tomici primi est, id pone deciduorum primum est, ad illius secundique intervallum: quod secundi, id similiter pone deciduorum secundum, ad intervallum illius et canini. Cavernulæ caninorum novorum tantummodo aliquantum ultra sundum præsepioli, cui deciduus inhæret, pertinentes, inde in angustum canaliculum abeunt, antequam abeant in eum, sensim contractiores. Maxillarum novorum cavernulæ nullo ad maxillæ marginem foraminulo pertinent. Hos invenio in fundum præsepioli decidui penetrare, et primum quidem juxta internam partem radicem ejus.”

Acad. Annotat. lib. ii. p. 13, 14 and 15.

† Hunter's Natural History of the Teeth.

in a fœtus of seven or eight months; and five or six months after birth the ossification begins in them; soon after birth the pulp of the second incisor and cuspidatus begin to be formed, and about eight or nine months afterwards they begin to ossify; about the fifth or sixth year the first bicuspis appears; about the sixth or seventh the second bicuspis, and the second molaris; and about the twelfth, the third molaris or dens sapientiæ." It is evident that this description is entirely theoretical, and not deduced from anatomical observation; for not a single point of it will agree with what I have already demonstrated. However, Mr. Hunter has arranged his plates in such a manner as to make them correspond in some degree with his doctrine; for instance, in his plate ix, fig. 6, the teeth of a child six or seven months old are represented; some of the temporary incisores were so far advanced as to have nearly cut the gum; the shells of the permanent incisores, cuspidati and anterior grinders were a little advanced, but the cuspidati had not commenced in the upper jaw, yet, he says, they are the teeth of a child eight or nine years of age. This error must surely be attributed to the printer.

But in plate x, fig. 1, accompanying his Natural History of the Teeth, he represents the teeth of a child five or six years of age, where only the anterior bicuspidates of the upper jaw had commenced, the middle grinders had not. In the same plate, fig. 2, the teeth of one side of both jaws of a child of seven years of age are represented; all the succeeding teeth had commenced; but even at this period the middle permanent grinders had not. He mentions, "This is an age in which there are more teeth formed, and forming than at any other time of life," though the entire number by his calculation amounts to but forty-four. When I come to treat on the shedding of the temporary teeth, we shall find that some of the permanent incisores appear through the gum before seven years; or that the roots of some of the temporary teeth, instead of being perfect as Mr. Hunter has represented them, are entirely wasted. Again, in plate xi, fig. 2, similar mistakes have been committed, for he says, in a youth about eleven or twelve years old, the two first

molares of the second set were so much advanced that they had cut the gums. Now these teeth in general appear about the sixth or seventh year; and in the same plate he represents the bodies of the middle and posterior grinders only as slightly formed.

It is unnecessary to recapitulate what I have demonstrated in the commencement of this chapter. Indeed it appears as an established law of nature, that there should be more teeth formed and forming at four or five years of age, than at any other period of life, that is, in all fifty-two. Yet, Mr. Hunter has represented at seven years only forty-four, and at nine years forty-eight, excepting that at the latter period the middle temporary incisores of the under jaw had been shed. Although I omitted saying any thing particularly respecting the formation of the permanent teeth, when treating of the ossification on the pulp of the temporary; I think, however, from the observations then made,* a few words more will now suffice.

The incisores and cuspidati resemble their predecessors but are much larger, but those which succeed the temporary grinders differ very much from them, in size and shape, being about one third smaller. Ossification commences on them in general by two points, the shells formed round each of these points gradually unite, and ossification goes on then for some time as in the incisores and cuspidati, until the greater part of the root is formed, which commonly divides in the upper jaw into two processes near the extremity. I have met sometimes two distinct roots proceeding from the neck; in the under jaw in general they have but one root. Now the grinders which they succeed have four or five points on their grinding surface, and in the upper jaw they have commonly three distinct roots; in the under jaw two. Nor, according to the celebrated Albinus, do they differ only in their number of points, but in their entire figure, by which we can readily distinguish one from the other. Although the accurate Eustachius remarks, those of the under jaw in general want the internal point, I think the term bicus-

* Vide chap. ii.

pides, which Mr. Hunter has given them, sufficiently applicable, as it once distinguishes them from the temporary grinders; on which account I retain it, particularly as it has been the term made use of in practice for some years since.

As to the permanent grinders, the anterior have each five points, the middle grinders four, sometimes five points, and the posterior or wisdom teeth three or four. In other respects their formation is exactly similar to that of the temporary grinders, but they are much larger. In the under jaw they have in general two roots, in the upper three, but the posterior, though they have sometimes, two, three, or even four distinct roots, seem most commonly to have but one.

CHAPTER V.

OF THE INCREASE OF THE JAWS.

IN a fetus three or four months old, the rudiments of the teeth are placed nearly regular; but as they increase more rapidly than the arch of the jaws, we find some of them at birth as it were pressed out of the circle for want of room, particularly the cuspidati; so that the sockets of the lateral incisores and those of the anterior grinders nearly come in contact. However, the jaws gradually accommodate themselves to the teeth, and increase at this part nearly in proportion to the size of the cuspidati, becoming again regular, for, indeed, we seldom or ever meet the temporary teeth irregular. This Mr. Hunter allows, but says,* "The jaw still increases in all points till twelve months after birth, when the bodies of the six teeth are pretty well formed; but it never after increases in length between the symphysis and the sixth tooth; and from this time, too, the alveolar process, which makes the anterior part of the arches of both jaws, never becomes a section of a larger circle; and after

* Hunter's Nat. History of the Teeth.

this time the jaws lengthen only at their posterior ends." Mr. Hunter supposed, as the temporary grinders are larger than the bisuspides which succeed them, that the difference in size of these would be sufficient to allow the permanent incisores and cuspidati, which are much larger than their predecessors, to become regular, without any increase of the arch or circle. He was led into this opinion by comparing four lower jaws of different subjects, and at different periods of life; from the age when the five temporary teeth are completed, to that of an entire permanent set. He acknowledges, however, that it is impossible there should be a mathematical exactness in four different jaws; nor, indeed, is there a mathematical exactness in the lines drawn to support his theory, for they are by no means parallel.*

Indeed, so varied are the dimensions of jaws, that the arch of one a year old may correspond, or even exceed the arch of an adult; and *vice versa*, the arch of an adult may be nearly as large again as that of a child; so it is not by comparing different jaws together that we shall be enabled to draw proper conclusions; but by comparing the permanent and temporary teeth of the same jaw.

It appears from my preparations, and experience convinces me, that the space occupied by the temporary teeth would not be sufficient to accommodate the same number of permanent teeth which succeed them, and which, on the whole, are so much larger, particularly in the upper jaw. This fact Mr. Hunter was aware of, and mentions that irregularities are more frequently met with in the upper than in the under jaw; so far I agree with him.

We have seen the rudiments of the permanent teeth at first placed nearly regular, but as ossification advances on them, they become crowded together for want of room. This irregularity particularly happens to the permanent teeth, because they are at first situated at the internal part of the jaw, and of course in a much smaller circle than the temporary. In the under jaw

* Hunter's Nat. Hist. of the Teeth.

the lateral permanent incisores hide nearly half the middle ones, and the lateral incisores and anterior bicuspidates are so close together, that the cuspidati would not have near room enough to pass up between them. In the upper jaw there is a much more confused appearance, and a more striking contrast with respect to the difference in size of both sets of teeth, the lateral incisores rest in part on the middle ones, and the sockets of the lateral incisores and anterior bicuspidates nearly come in contact; so that the cuspidati are entirely thrown out of the circle. We have seen also that the pulps and membranes of the permanent teeth were at first very small, and that the sockets were in proportion; but as the pulps enlarged and ossification advanced on them, the sockets increased likewise. It is but just, therefore, to suppose, that as the teeth rise and appear through the gum, the alveolar processes should accommodate themselves to them; which, indeed, will presently appear to be the case. If Mr. Hunter was a practitioner in this branch, even with very little experience, he must have frequently observed in children of about six or seven years of age, (if the first teeth had not already fallen,) large distances between the incisores, which at first were quite close to one another. I have seen hundreds of instances in which the four permanent incisores appeared irregular, but in a short space of time became perfectly regular without any artificial assistance. In a preparation of Dr. Munro's, (which he was kind enough to allow me to take a sketch of,) the four permanent incisores of the under jaw had appeared, and also the two middle incisores of the upper, and were perfectly regular, though the temporary cuspidati and grinders had remained in, in the former, and the lateral incisores, cuspidati and grinders in the latter. Surely then, these teeth could have gained no room from the difference in size of the grinders and bicuspidates; it must, therefore, be owing to an increase of the arches of the jaws in these parts, exactly in proportion to the difference in size of the temporary and permanent incisores. There is still in this case a further necessity for a considerable increase of the arches, on account of the irregular situation of the permanent teeth as well as because several of them had not as yet arrived at their full size.

The pressure of the front teeth on one another as they rise in the jaw, appears to have some effect in occasioning it to extend at certain parts, or to make the grinders move backwards, to which, indeed, all the teeth have a tendency. I have a preparation of the upper jaw of an adult, in which the temporary cuspidatus of the right side remained in; the permanent cuspidatus probably from the resistance of the former, penetrated at the internal part of the mouth; in the left side the teeth are all perfectly regular: on comparing the situation of the anterior permanent grinders, I found that of the right side nearer the symphysis, than that of the left in proportion to the difference in size, of the temporary and permanent cuspidati. I have met several instances of the permanent cuspidati appearing at first irregular, as they most commonly appear later than the bicuspidates, but in ten or twelve months after the jaw increased sufficiently, so as to allow them to become regular. I have met many cases where the arches of the jaws continued to increase, even after the permanent teeth were complete; so that all the front teeth were quite separate from each other; and in one case the middle incisores were nearly half an inch asunder, though there was no defect in the palate.

From what is now said I feel myself justifiable in concluding, that the alveolar arches continue to increase during the entire progress of the formation of the teeth; it is, however, sufficiently evident, the greatest increase of the jaw is backwards. I do not by any means deny but that we frequently meet with disproportions between the jaws and teeth, and such that the permanent teeth never would become regular without the assistance of art, even in young persons; this may arise from the resistance of the temporary teeth, or from teeth forming so much out of the circle that they have not sufficient power to act on their neighbors and press them back, such as the cuspidati, which are most commonly irregular. Indeed, if Mr. Hunter's hypothesis were true, we would never see a regular set of teeth.*

* The permanent incisores occupy all the space previously occupied by the temporary teeth of the same class, and about one-half of the space

CHAPTER VI.

OF THE SHEDDING OF THE TEMPORARY TEETH, AND OF THE PERIOD AT WHICH THE PERMANENT APPEAR.

WE meet with such strange opinions in the works of a celebrated author (Van Swieten) respecting the temporary teeth, that I think it worth while to insert some extracts from them: He says, "I have taken out and examined several of the first teeth when they begin to loosen, and in most of them I did not observe the slightest appearance of a root. This surprised many surgeons, who, in the treatment of disorders of the teeth, were esteemed exceedingly skilful. They were of opinion that the teeth which are usually shed about the seventh year had roots, but when they took out those that were already loose, they found no roots. To account for this, they said that the second tooth while it rises, rubs away the roots of the first, and so reduces them to the most minute powder, which, being so very fine, entirely disappears, for no body could ever perceive it. But could the action of the second tooth, gently rising, whilst it moves the first out of its place, be so great as to reduce the roots of them to powder? Bourdet, celebrated for his skill in this branch of surgery, asserts, that the first teeth before they loosen have roots nearly as strong and hard, as the second are observed to have. And whilst he refutes the opinion of Bunon, who supposed the

occupied by the temporary cuspidatus. The remainder of this space, and a fractional part of the space occupied by the first temporary molar, is occupied by the permanent cuspidati, and the bicuspidates are thus compelled to occupy a space greater than that occupied by the first, and second temporary molares. The more frequent liability of the permanent teeth to irregularities is not, however, explained by this fact; but is accounted for by the abnormal condition of the parts.

That the jaws increase in size, cannot be questioned, but this increase is principally in their length, still, there is some increase in the size of the arch, but, which never occurs until the loss of the temporary teeth takes place, and then, by the teeth of replacement arranging themselves in an alveolar border, which describes somewhat a larger circle.—*Ed.*

roots of the first were destroyed by the friction of the second teeth when rising, he refers to those which are found in the jaws of fresh subjects, at that period when the second teeth are forming; and the first (called milk teeth) are still in their sockets; whether they are still firm, or are more or less loose. For it seems that the second tooth whilst it rises, remains enclosed in its proper membrane, until it is about to appear. Therefore, a membrane is interposed between the roots of the milk tooth and the second tooth. However the roots of the milk teeth are destroyed before the second teeth can touch them. Besides a small space is observed between the first and second tooth, from whence Bourdet concludes, that the roots of the milk teeth are destroyed by some other cause, and not by the friction of the succeeding teeth. He, therefore, thought that some acrid humor was secreted from the neighboring parts, which might consume their roots. I must confess it appears to me much more probable, that the milk teeth are without roots.

“Nevertheless some observations seem to show that the milk teeth, if they are not shed at the proper period, or when loose are not taken out. are capable of protruding roots from their body, by means of which they often remain fixed in the jaws through life.”*

* “Plures dentes primos, dum vacillare incipiunt, eductos examinavi, et in plurimis ne vestigium quidem radicis inveni. Mirabantur hoc chirurgi peritissimi, qui in dentium morbis curandis versatissimi merito habebantur. Statuebant, dentes, qui circa septimum annum cadere solent, radices habuisse: dum illos, jam vacillantes, levissimâ vi educebant, nullas radices inveniebant. Ut hoc explicarent, dixerunt, secundum dentem, dum assurgit, atterere radices prioris, et sic comminuere in minutissimum pollinem, qui præ tenuitate suâ evanesceret totus; nam nemo illum unquam invenit. An lentè ascendentis dentis secundi, dum primum loco movet, actio tanta esse potuit, ut prioris radices in pollinem comminuere? Egregius in hac chirurgiæ parte *Bourdet* statuit, primos dentes, antequam vacillent, habere radices æque fortes fere, at duras, quàm observantur in secundis. Dum autem refutat sententiam *Bunon*, qui statuebat, radices illas a frictione ascendentis dentis secundi destrui, provocat ad illa, quæ in recentis cadaveris maxillis inveniuntur, dum secundi dentes jam ossei fieri incipiunt, et primi dentes, (lactei dicti,) adhuc adsunt; *sive firmi adhuc hæreant*, sive jam plus minùsve vacillare inceperint. Apparet

It is almost superfluous to mention that the temporary teeth have as perfectly formed roots as the permanent, indeed, as far as I recollect, Van Swieten is the only person who at all doubted the fact.

Mr. Hunter ingeniously observes,* “An opinion has commonly prevailed, that the first set of teeth are pushed out by the second; this, however, is very far from being the case: and were it so, it would be attended with a very obvious inconvenience; for were a tooth pushed out by one underneath, that tooth must rise in proportion to the growth of the succeeding one, and stand in the same proportion above the rest.” Mr. Hunter, however, does not seem to be acquainted with the writings of the very accurate Albinus; if he was, he would be induced to give a very different description of what takes place, with respect to the wasting of the roots of the temporary teeth and the appearance of the permanent, as will appear from the following quotations. Mr. Hunter says,† “It would be very natural to suppose that this wasting was owing to a constant pressure from the rising teeth against the fangs or sockets of the first set: but it is not so; for, the new alveoli rise with the new teeth, and the old alveoli decay in proportion as the fangs of the old teeth decay, and when the first set falls out, the succeeding teeth are so far from having destroyed, by their pressure, the parts against which they might be supposed to push, that

enim, dentem secundum, dum assurgit, suâ membranâ involutum manere, donec exitui proximus sit. Radicibus ergo dentis lactei et assurgenti denti secundo interponitur membrana. Radices tamen dentium lactecrum destructæ jam sunt, antequam secundii dentes illas tangere possint. Præterea parva distantia observatur inter dentem primum et secundum; unde concludit, radicem dentis lactei consumi ab aliâ causâ, non verò per attritum dentis suppositi. Hinc maluit credere, ab adjacentibus partibus secerni acriorem quemdam humorem, qui illas radices consumeret. Fæctor quòd mihi longe probabilior videatur opinio, quæ statuit dentes lacteos carere radicibus. Videntur tamen observationes doctoe, quòd dentes lactei, si non cadant suo tempore, aut jam vacillantes non eximantur, apti sint, ut radices protrudant ex suo corpore, quibus postea fixi in maxillis hærent sæpe totâ vitâ.

* Nat. Hist.

† Nat. Hist.

they are still enclosed, and covered by a complete bony socket. From this we see, that the change is not produced by a mechanical pressure, but is a particular process in the animal economy." And, again, he makes use of the following words, "When the incisores and cuspidati of the new set are a little advanced, but long before they appear through their bony sockets, there are small holes leading to them on the inside, or behind the temporary sockets and teeth; and these holes grow larger and larger, till at last the body of the tooth passes quite through them." Mr. Hunter supports this theory still farther, "As the body of the tooth is pushed out, the socket at the same time contracts at its bottom, and grasps the neck, or beginning fang, adheres to it, and rises with it, which contraction is continued through the whole length of the socket as the fang rises; or the socket which contained the body of the tooth, being too large for the fang, is wasted or absorbed into the constitution, and a new alveolar portion is raised with the fang." These observations of the ingenious Mr. Hunter are, however, entirely hypothetical and do not accord with anatomical truth; indeed, they entirely overturn some of his former opinions. For if, as he affirms, the permanent teeth were formed, at the internal part of the jaw and in a new series of alveolar processes, it is evident that they must necessarily be placed in a smaller circle than the temporary teeth. And if the processes and sockets of the temporary teeth, as Mr. Hunter asserts, were absorbed or totally destroyed, the permanent sockets should extend to the anterior part of the jaw, accommodate themselves to the teeth and thus form a segment of a larger circle.*

Albinus, however, comes very near the truth, for when speaking of the holes by which the connection between the membranes of the permanent and temporary teeth were preserved, he says, "As the new teeth increase, the contracted part of the sockets is gradually dilated, and afterwards in like manner the little opening, and thus they appear. But if previous to the formation of the new teeth, the temporary had fallen out, or

* Vid. chap. v.

were loosened in consequence of their roots being wasted, then the socket of the temporary tooth is gradually destroyed, while that of the other being dilated anteriorly, the new tooth passes into its place, so that the root of the new tooth is contained in a socket formed partly of that in which it was before, and partly of the socket which belonged to the temporary tooth. But if contrary to what commonly happens, the tooth which ought to be shed, is not shed, then the permanent tooth appears behind it and remains similar to it fixed in its own appropriate socket.”*

Had Albinus been acquainted with the use of the small holes leading to the permanent teeth, he would immediately have discovered what usually takes place.

I have already shown that the temporary and permanent teeth were about the fourth year, separated from each other by a bony partition, each being at this period contained in a distinct socket. Now, according as the permanent teeth rise, they have a natural tendency to come more and more to the anterior part of the jaw; whilst in consequence of the pressing forward of the rising tooth, a change is induced in the mode of action of the surrounding vessels, such, that that portion of the bony partition immediately pressed upon, as well as the root of the temporary tooth, with the adjacent parts, become fit to be absorbed, and actually are absorbed.

In some cases part of the roots of the neighboring temporary teeth, are absorbed; particularly where the jaw does not increase as rapidly as the permanent teeth. So that in proportion as this absorption takes place, the permanent tooth passes partly into the socket of the temporary tooth proper to it, and partly

* “*Crescentibusque novis, sensim dilatatur cavernularum pars illa contractior, posteaque et ostium: ac sic erumpunt. Si autem, novi antequam nati sint, decidui ceciderint, aut perdita radice plane vacillent, tunc sensim simul deletur decidui præsepiolum, novique cavernulâ antrorsum dilatatâ, hic in locum illius succedit ut ex novi cavernula, partem præsepioli decidui, præsepiolum, quod novi radicem contineret, formaretur. Sed si quando non decidit is, qui cadere debuit, tunc novus pone eum nascitur, suo inhærens præsepiolo, ut prior ille.*” Acad. Annot. lib. ii. pag. 14 et 15.

into the sockets of the neighboring temporary teeth. And, as Albinus justly remarks, a socket is formed for the reception of the root of the new tooth, in part, by its own appropriate socket, and in part by the temporary socket of the tooth with which it was originally connected, and sometimes in part by the neighboring temporary sockets.* When the permanent teeth pass into the cavities which surrounded their membranes, they are always very irregular and appear as Albinus remarks at the inside of the temporary teeth, which frequently remain in their situation. This irregularity, however, is seldom the case, unless where the temporary teeth retain their roots, and resist the influence of the permanent. In some cases they appear more internally than the cavities through which the connecting membranes passed. It is worth remarking, that when the temporary teeth fall out, if we examine their bodies we find them quite excavated, and the bony part reduced nearly to its former pulpy state.

Mr. Hunter, in support of his theory, has represented the wasting of the roots of the temporary teeth, as it were proceeding from the point gradually upwards to the neck.† This, however, is seldom or never the case, for the part first affected is considerably above the point. This circumstance Albinus was fully aware of, and has given drawings to illustrate it.‡

With respect to the appearance of the permanent teeth, Dr. Hudson in a letter he wrote to me at Edinburg, judiciously remarks, "The time of shedding is very various, happening a year or two or three earlier or later in some than others; and in many subjects some of them remaining to adult or even old age; and this is so common, that almost every day I meet with them, from one to three or four, or double the number, in the same person. I have seen two instances where scarcely any of them fell, and such I may affirm must have been those historic facts handed down to us, of a third set appearing in the old age

* This fact is very beautifully exemplified in a preparation of the head of a young horse in my possession.

† Hunter's Nat. Hist. of the Teeth, plate xv.

‡ Acad. Annot. lib. 11. tab. ii.

of heaven-favored mortals, where it could be nothing else than the then matured second set. Such I have met with, but never any thing like a third set, at least, which I was convinced was such." It appears from the foregoing observations, that the permanent teeth, whilst they are rising in the jaw, have considerable influence with respect to the wasting of the temporary roots; for while they are at rest, the roots of the temporary teeth are not wasted. However, it does not appear to me, that the wasting of the temporary roots, is in any degree the effect of mechanical trituration, as Mr. Bunon and other authors would affirm.*

*The beautiful operation of nature, which works the destruction of the fangs of the temporary teeth, that they may give place to their more hardy successors, which shall more fully answer the demands of nature, has given rise to a great number of theories by which such results are effected.

Bourdet more satisfactorily explains this subject, than any other, by the discovery of a bud-like body immediately below the deciduous tooth, at the point where destruction of its fang is marked, composed of a body of a carneous appearance, which acts as the absorbing agent.

This bud-like or carneous body, is the coat of the sac of the permanent tooth that extends from the latter to the gum. When the perfection of the permanent tooth demands its elevation, the superior portion of the sac, changes its color from a pale red, to a deep red hue, indicating an increased vascularity of this portion of the organ, which acts as the absorbing agent, and ever keeps in advance of the outer progress of the permanent tooth, and between it, and the fang of the temporary tooth, consuming or absorbing not only its fangs, but all else that would oppose the progress of the advancing tooth.

Dr. W. H. Elliott, in a paper read before the American Society of Dental Surgeons, and published in the first number (October No. 1847) of the eighth vol. of American Journal and Library of Dental Science, states a case of a child having suffered from an alveolar abscess over the right superior central incisor of the temporary set. A year subsequent to the above period, Dr. Elliot examined the mouth of this patient, and removed the right superior central incisor, which had been immediately surrounded by inflammation; and found that its fang was not at all absorbed, whereas the fang of the left superior central incisor, which was also removed, was entirely absorbed. In a few weeks following the operation, the crown of the permanent right superior central incisor cut the gum, although the fang of its predecessor was not absorbed, while at a later period, of some weeks,

In general, children begin to shed their teeth about six or seven years of age, and the permanent appear nearly in the following order: First, the middle incisores of the under jaw, soon after, those of the upper; then the lateral incisores of the under jaw, and nearly at the same time the anterior grinders; then the lateral incisores of the upper jaw appear, though some time elapses between their appearance and that of the former: the anterior bicuspidæ appear about the ninth year, the posterior about the tenth or eleventh, and the cuspidati and middle grinders nearly at the same time, that is about the twelfth or fourteenth year, and, finally, the posterior grinders or wisdom teeth from the sixteenth to the twenty-fifth year. Though, as Dr. Hudson remarks, there are many exceptions to this general rule, yet I do not think it necessary to dwell so much on the order or period of their appearance, as I have done with respect to the temporary.

The anterior permanent grinders frequently appear a considerable time before any of the temporary teeth are shed, and

the crown of the left superior central incisor had not cut the gum, although the fang of its predecessor was completely destroyed. Dr. Elliott makes the following deductions from the above case, viz.

1st. "That an increased, but healthy deposit of dental substance may be produced by local irritation."

2d. "That absorption of dental bone, may be induced by local irritation." And that the periosteum of the temporary teeth contain absorbents capable of removing them, and by applying a stimulant they will attack every thing in contact with them; thus, accounting for the absorption of the fang of the left superior central incisor.

I would, however, respectfully propose a different interpretation of the above case. The inflammation about the fang of the right superior temporal incisor was so great as to destroy not only the soft tissues and alveolar walls about this tooth, as shown in the original report of the case, but this carneous body that lay superior to the tooth of replacement, and prevented the absorption of its fang; but the inflammation not extending itself sufficiently deep and broad, acted on the tooth of replacement and its organs as a stimulant, and hastened its development, and exerted a similar stimulating effect on the carneous substance surrounding the left superior temporal incisor, and its vascularity being increased, resulted in the early absorption of the fang of the tooth last named, and its successor not being subject to this stimulus, from its position, did not correspondingly prematurely advance.—*Ed.*

there are many varieties with respect to the wisdom teeth, for in some cases they do not appear till a very late period of life, sometimes they appear in one jaw and not in the other, and sometimes it has been observed that in extreme old age they have not perforated the sockets.* It is certainly a curious fact, how very long some of the permanent teeth remain within the jaws, without appearing; and if there ever was a third set of teeth, it is sufficiently evident, that their rudiments must have been deposited, previous to the appearance of the second set through the gum.†

*The appearance of the permanent teeth is very irregular, being dependent on many contingent causes. The first permanent molar is more regular in its appearance than any other of the permanent teeth. The following periods may be said to comprise the periods between which the permanent teeth are erupted during normal dentition. The first permanent molares appear between five years, and six and a half years of age; the central incisores appear from six and a half to eight years of age; the lateral incisores from seven to nine; the first bicuspidates from nine to ten; the second bicuspidates from ten to twelve; the cuspidati from eleven to twelve and a half; the second molares from twelve to fourteen; the third molares from seventeen to twenty-one.—*Ed.*

† The occurrence of third dentition is no longer a question of doubt, as it has been too frequently demonstrated by nature to satisfy the most incredulous. Hitherto, this operation of nature had not met with a satisfactory explanation. We find, however, this breach in developmental anatomy filled by the physiological explanation of this phenomena, by Prof. Harris, in the first number of the eighth volume of the *American Journal and Library of Dental Science*. Professor Harris observes:

1st. That the rudiments of the first and second dentition are the product of mucous membrane.

2d. That the condition and location of a part, determines the function which it performs, as in the case of first and second dentition. The mucous membrane, in the first case, assumes along the alveolar border, a grooved or duplicated appearance, when a dental papilla shoots from it, and when a similar duplicature of this same membrane is formed behind the cavity of reserve of the first teeth, the papilla of the permanent teeth makes their appearance from its base. The presence of a papilla is a call or demand for the development of its investing membrane.

3d. That the third set of teeth originate from the mucous membrane, which is placed in the peculiar position which throws upon it the peculiar function of producing the dental organs, by accidental causes, and

CHAPTER VII.

A FEW PRACTICAL OBSERVATIONS RESPECTING THE TEMPORARY TEETH.

I APPREHEND that Mr. Hunter's theory respecting the increase of the jaws, has led him and those who followed his directions, into egregious practical errors; he makes use of the following words: * "From the manner in which the teeth are shed, it is evident that drawing a temporary tooth, for the easier protrusion of the one underneath, will be of no great service; for, in general, it falls out before the other can touch it. But it is often of much more service, to pull out the neighboring, or adjacent temporary tooth; for we must be convinced by what has been advanced with regard to the changes in size, that excepting the whole were to shed at the same time, or the order of shedding, viz. from before backwards, were to be inverted, that the second set of incisores and cuspidati must be pinched in room, till the grinders are also shed: and, therefore, we find it often of use to draw a temporary tooth, that is placed further back; and it would, perhaps, be right upon the whole, always to draw, at least the first grinder; and, perhaps, some time after, the second grinder also."

the germs are not developed in the jaws at the time when those of the first and second set are.

4th. That these accidental organs seldom have roots, or if they do, they are short and blunt. This results from the absence of their alveolus, in consequence of the maxillaries having attained their size previous to such dental formations.

5th. That these accidental duplications of the mucous membrane that produce these organs in question, and are placed in this position, may result from the extraction of a tooth. The granulated walls of the gum surrounding the alveolus of the extracted tooth, may become covered with this tissue before the cavity is filled with a deposit of new bone, so as to prevent a complete union after they have come together. Thus, is third dentition accounted for on physiological principles, strictly in accordance with anatomical development.—*Ed.*

* Hunter's Nat. Hist. of the Teeth.

I need scarcely observe that this mode of treatment is altogether improper. The practice which Dr. Hudson of this city introduced nearly forty years ago, and still retains, entirely coincides with my observations; he was fully aware of the increase of the jaws, which appears from these, his remarks, "The indiscriminate practice of drawing children's teeth before they loosen is erroneous: the intent of making greater room for the second set is thereby directly defeated. Let the propriety be hence inferred of a timely and regular domestic attention to the teeth and gums, it will prevent many painful disorders and operations, and leave nature undisturbed in the production of the permanent teeth, to the great disappointment of the expecting charlatan." There are some exceptions, however, to this general rule; for it is necessary sometimes to remove a few of the temporary teeth: if the roots of these teeth are not wasted in proportion as the permanent teeth rise in the jaw, thereby affording such resistance, as to occasion them to appear at the internal part of the mouth: or where the jaw does not increase in proportion to the difference in size of the temporary and permanent teeth, by which means the permanent teeth are turned quite across in the sockets. The propriety, however, of performing such operations must be left to the judgment of the practitioner. The operations recommended by Mr. Hunter, I look on to be very injurious, for that pressure or proper degree of resistance and connexion (were the temporary teeth taken out prematurely) would be removed, which seems to me altogether necessary to the perfection of the permanent teeth.*

* The cases which will justify the extraction of the temporary teeth are limited: One is, when extensive decay has produced great pain, from which the little patient's general or local health is greatly disturbed. Another is, when the tooth of replacement appears through the gum, and takes up a position either behind, or in front of the corresponding tooth. It should be recollected, however, that the presence of a full and complete set of teeth is necessary for the perfect development of the arch in which they are placed, and that their removal is an evil, resulting, oftentimes in a contracted alveolar arch, and irregular and deformed second dentition. The temporary teeth may be extracted too soon, or left in too long, for the regular arrangement, and healthy formation and condition of the permanent teeth.—*Ed.*

It would be quite foreign to the nature of this essay, to enter into a description of the great variety of disease to which the teeth and gums are subject. Let us suppose, however, that some of the temporary teeth are diseased, or what is commonly called carious; if they are so far injured as to occasion violent pain to the child, and if palliative remedies fail to give relief, we cannot hesitate about the propriety of taking them out. Having already observed that the alveolar processes of the temporary teeth are not obliterated or absorbed, as Mr. Hunter supposed, we should be very careful lest diseases of these teeth or gums should materially injure them, which indeed is too often the case. When the caries of a tooth has proceeded so far as to communicate with the cavity where the vessels are contained, the ichorous matter, or the air admitted into the cavity coming in contact with the membrane of the pulp, occasions an inflammation of it, which frequently communicates with the external periosteum of the root. When the inflammation has advanced to a certain degree, suppuration takes place, and a considerable sac or abscess is thus formed, which being filled with purulent matter, occasions an absorption or wasting of the alveolar process near the apex of the root, and in this way a passage is at last made through the process, forming what is commonly called a gum-boil. The opening is usually made between the cheek and jaw, sometimes, however, it bursts externally, and leaves a disagreeable cicatrix or scar through life. So that in such cases the necessity of removing the temporary teeth is obvious, in order to avoid such distressing consequences as these, and others which are even yet more particularly dangerous.

It is the opinion of many celebrated anatomists, that diseases of the temporary teeth cannot injure the permanent, even though the diseased parts were to come into contact with them. I am sorry to say I have seen many instances of the contrary; though previous to my having observed the connecting membranes, I was totally at a loss how to account for the injuries communicated from one to the other. The following case, which occurred to me about six years ago in this city, will illustrate the subject remarkably well.

A lady brought a child to me about six years old, to have the anterior temporary grinder of the under jaw taken out; the tooth was very much diseased, and the point of one of the roots stuck out of the jaw, and occasioned an ulceration of the cheek. On inspecting the mouth, I found the tooth quite loose, and a considerable portion of the alveolar processes attached to it, which had been separated from the neighboring or sound parts. I removed the entire with a curved probe, and having immersed the extracted portion in water, in order to examine it, I found it to consist of the entire socket of the temporary tooth, and also the socket in which the bicuspid was forming, part of the body of which was tolerably advanced; the earthy matter of the cortex striatus was quite black, and perfectly soft. The sockets of the neighboring teeth fortunately were not much injured. On inquiring into the history of this case, I was told that about two years previous the child had had a slight fit of the tooth-ache which subsided, and soon after a gum-boil was formed, which frequently suppurated and burst, after which the child would get relief for some short interval. The mother, through timidity, or false affection for the child, could not be prevailed on to consult any one, until forced to it by the consequences already mentioned. The child without any other assistance got well, but the jaw remains very much contracted where the tooth was, with a corresponding hollow in the cheek.

I have since that period met three or four cases, where two or three of the permanent teeth were sloughed off by a similar cause. These cases I account remarkably instructive, for they clearly point out the necessity of removing the temporary teeth, when any such ulcerations or gum-boils are forming, particularly if they are of great extent, or long continued. Slight cases, however, if properly attended to, might be retarded, and, probably, entirely checked.

CHAPTER VIII.

OF THE TEETH IN VARIOUS CLASSES OF ANIMALS.

As well the structure as formation of the teeth of graminivorous and ruminant animals, differ from what is observed to take place in those of the carnivorous order. The food of the former requires a greater degree of comminution than that of the latter; for which purpose it becomes necessary, that the surfaces, between which this operation takes place, shall be as much as possible multiplied. That this object is fully provided for by nature, may be evinced by inspecting the grinding surfaces of their teeth; for the *cortex striatus* not only covers the body of the tooth, but even descends through its substance, forming therein a variety of convolutions, and, of course, a variety of prominences in each accidental section of it; such parts of it being less liable to abrasion, than the other bony portion of which it is composed.

Many circumstances, however, particularly relative to their structure and formation, have not been as yet at all attended to or explained, on which account I have endeavored to trace them at different periods.

In the right side of the lower jaw of a *fortus* calf about three months old, the internal plate of the alveolar process being cut away, and the arteries injected, the rudiments of the teeth, in a follicular state, were made visible.

The upper part of the pulp of a grinder is divided into a certain number of conical processes, previous to the commencement of ossification upon it; the number of these processes varies according to the size, or kind of tooth; in some there is but one, in others two, four, or six of them. The pulp of the great grinder of the under jaw in the calf just now mentioned, was divided into six processes, and on it as many bony shells were already formed. As ossification advances, the processes of the pulp elongate, whilst the bony shells extend considerably on them previous to the junction of their sides; they then form

one continued shell, exhibiting no trace whatever of their former separation. From the convulated shape of the pulp, deep depressions are left at the junction of some of the shells, which are situated at the internal part of the mouth in the upper jaw, but at the external part in the under. In order to fill up these, or to strengthen the tooth, one or two additional processes are sent off from the pulp, when ossification has advanced somewhat on the original pulps, or when the sides of the shells have been nearly united. These processes, however, do not rise to an equal height with the first, the upper teeth have but one of them, the under in general two.

The membranes which are intimately connected with or derived from the internal part of the gum, can be easily separated into two lamellæ, the external of which is very vascular, though I could not trace a single blood-vessel entering into the internal one; this appearance is best examined in fœtus calves about three or four months old. These membranes surround the pulp, and duplicatures of them pass down between the internal divisions of it, exactly similar to the passing of the *pia mater* between the convolutions of the brain. The duplicatures extend downwards until checked by the junction of the internal plates of the shells, which thus separates them from the pulp. As soon as the bony shells are perceptible, the internal part of the membrane secretes and deposits on their points and progressively on their sides, a soft earthy matter similar to moistened chalk, and is itself moistened with a mucilaginous fluid, a great quantity of which is found between the membrane and shells. This soft earthy matter gradually assumes the crystalline appearance of the cortex striatus, the fibres of which are in contact with the membrane, the bony part in contact with the pulp.

When the cortex striatus is perfectly formed down to the bottom of the convolutions or junction of the internal plates of the shells, the tooth begins to rise by the increase of its roots ;*

* In the ordinary ruminants, the superior bicuspidæ have three fangs, two external and one palatine; the inferior bicuspidæ have two fangs; the superior molares have four fangs, two external and two palatine; while the inferior molares have two only, but the second fang in the last mo-

the upper part of the investing membrane at the same time wasting in proportion as the cortex striatus covered by it attains to perfection, so that the tooth advances by almost imperceptible degrees until at length it appears through the gum. The protuberances of the tooth first appear, and thus intercept part of the nourishment from the duplicatures of the membrane which passed down into the internal cavities. When the tooth rises somewhat higher, all nourishment is cut off from the internal duplicatures of the membrane which are then found dead and of a darkish purple color. The lower part of the membrane, however, remains on the external plates of the body of the tooth, but is wasted in proportion as the cortex striatus becomes perfect. The entire bodies of the temporary teeth when formed pass through the gum, so that the whole of the investing membrane is destroyed as soon as they have risen to their proper height.* This description, however, admits of a few exceptions, particularly with regard to the permanent grinders, the greater part of whose bodies remains within the jaw for a considerable time. A purpose of some consequence in the animal economy, which I shall presently endeavor to explain, is thus answered; and, as the process by which it is completed is

lar is very thick. The crowns extend some distance into their sockets before bifurcating, and their fangs increase in length with the age of the animal.

* The period at which the teeth of the calf are erupted, are given in the following order by M. Rousseau: The first deciduous incisores, and the first deciduous molares are erupted, or cut the gum a few days after birth; the lateral incisores and the second and third molares between the fifth and tenth days; the third incisores between the tenth and twentieth days, and the deciduous canine a few days later. Second dentition is commenced by the eruption of the first permanent molar between the fourth and sixth month after birth; the central incisores, and the second permanent molar appears between the fifteenth and twenty-second month, and about the last named period the first bicuspid appears in the place of the first deciduous molar; the second bicuspid and the lateral incisores appear between the twenty-eighth and thirty-second month, and which are followed by the eruption of the third bicuspid and third incisor between the thirty-eighth and forty-eighth month; the third molar cuts the gum between the forty-fourth and fifty-second month; the permanent canine is the last tooth erupted, and not before the ox has attained its fifth year.—*Ed.*

very different from what has been already described, it will be of use to point it out in the clearest manner. It appears that the internal part of the membrane secretes the earthy matter of the cortex striatus, and that as soon as it has performed its function it is wasted or destroyed; for its external lamella, as soon as the upper part of the cortex striatus is crystallised, begins to deposit on its surface a substance differing from either the bony part or the cortex striatus, being harder and more brittle than the former, and less so than the latter. It is likewise of a different color and can be readily distinguished from the other two component parts. As the surface of the cortex striatus is smooth, this substance (which, for distinction's sake, I take the liberty of calling the *crusta petrosa*) cannot adhere firmly to it, and for this reason in the teeth of young animals it easily chips or scales off, when they are exposed to the weather. In animals more advanced in life, the *crusta petrosa* fills up all the convolutions of the external plates of the cortex striatus, and extends a considerable way beyond them, so as to form a great proportion of the grinding surface, when it becomes much more consolidated, and with difficulty can be separated from the cortex striatus. The *crusta petrosa* not only covers that part of the tooth which appears through the gum, but also that part of it which remains within the socket, and in a few instances I have observed a small quantity of it on the roots of the teeth of very old horses. From this, and observations on the teeth of other animals, which will presently be mentioned, it would seem that the membrane may at once deposit this matter, without having previously given rise to the cortex striatus. The *crusta petrosa* is depositing on the upper part of the tooth a long time previous to the crystallization of the lower part of the external plates of the cortex striatus, and it continues to be deposited as long as any part of the body of the tooth remains within the socket.

The *crusta petrosa* seems intended to serve a variety of purposes: in the first place, to fill up the hollows in the sides of the teeth, next the cheek and tongue, and render them even. 2dly. To support and prevent the fibres of the cortex striatus from

splintering off or wearing down too rapidly. 3dly. To increase the grinding surface and render it more rugged, for it scarcely wears down as fast as the bony part, yet faster than the cortex striatus. In some few instances the grinders remain sufficiently long under the gum, so as to allow the cavities, in which the membrane passed down to form the cortex striatus, to be nearly filled by the crusta petrosa. In most cases, however, these cavities are filled entirely with the matter of the food, by the broken particles of the teeth whilst grinding, or by particles of sand, clay, &c. This adventitious matter remains quite spongy and of a different color and texture from any of the other three above described parts; in the cow it is of a blackish or dark brown color. It is remarkably evident in the grinders of the sheep, in which the cavities are constantly filled with particles of grass and clay; the structure and formation of their teeth being similar to those of the cow, except what regards the additional processes.

The crusta petrosa seems intended for another and a very important purpose. The greater proportion of the cortex striatus in graminivorous animals, as already mentioned, remains within the jaw for some years. Now the nature of this substance is such, that membranes could not adhere to it, whilst without the interposition of some such substance as the crusta petrosa, or a total want of the cortex striatus, a circulation of fluids through the socket could not take place. The crusta petrosa is, therefore deposited for the membranes to adhere to, and also to prevent the sockets being injured by the violent motions performed in grinding. It cannot be mistaken for a deposition from the fluids of the mouth commonly called tartar, for I just now mentioned that it is deposited previous to the appearance of the tooth through the gum. A similar substance I have observed on the grinders of the elephant,* rhinoceros, &c. and even on the grinders of the rabbit and hare, indeed, it is to be met with in almost all graminivorous animals.

* The structure and formation of the elephant's teeth, I reserve as a supplement to the present work.

The grinders of the camel are nearly similar to those of the cow, the internal cavities of their teeth are in like manner filled with particles of grass, clay, &c.*

The formation of the incisores and grinders of the horse differs very much from those of the cow, and, probably from those of all ruminant animals; for, as the horse does not chew the cud, it was necessary his food should be at once sufficiently masticated; his teeth and jaws of course are admirably fitted for this purpose.

The grinders of the upper jaw commence by four points of ossification, and are formed precisely similar to those of the cow, except that additional processes are not added, and that the internal cavities are mostly filled by the crusta petrosa; although I have sometimes observed the upper part of the cavities filled by the adventitious matter, while the under part of them was occupied by the crusta petrosa. This only happens where the ossification of the roots takes place more rapidly than the deposition of the crusta petrosa, so that by the tooth penetrating the gum the nourishment is cut off from the internal duplicatures of the membrane.

The formation of the grinders of the under jaw, however, differs very much in those animals; for though ossification commences in the horse on the pulp of the grinders, by five or six points, which afterwards increase into as many small shells, yet, as happens in the human subject, they unite, without duplicatures of the membrane passing down between them to form internal plates of the cortex striatus, which I before observed always takes place in the cow. This membrane, however, passes round the pulp in a very convoluted manner, and as the points of the shells and the interstices between them are soon

* It might be proper here to add, that a peculiar uniform feature or dental mark of the ox, is, the absence of incisores and cuspidati teeth in the upper jaw, and the apparent absence of canines in the lower jaw. Those teeth last named, are so modified in shape and position, as to resemble an incisor, under which class they are often described by comparative dental anatomists, and as the fourth pair, there being an addition already of the third incisor.—*Ed.*

worn away by grinding, a section is thus formed in which one continued line of the cortex striatus can be traced, including the bony part alone within it, the crusta petrosa remaining without. In all graminivorous animals the under jaw is much narrower than the upper, particularly at the anterior part, the under teeth are, likewise, at least one-third narrower, but by the lateral motion of the under jaw during manducation, different points of the under teeth can be successively applied to the whole surface of the upper ones, the lateral motion corresponding exactly to the difference in breadth of the upper and under teeth.

The pulp of a front tooth in either jaw of a horse is divided into two processes: duplicatures of the investing membrane pass down between them to a considerable depth. The cavity in the middle of each of these front teeth is filled by particles of the food, &c. and, sometimes, though seldom, by the crusta petrosa.* By the disappearance or wearing down of the edges of these cavities and internal plates of the cortex striatus, jockies determine the age of a horse, or (in their language) by the filling or growing up of the cavity. Indeed, so well acquainted are they with this circumstance, that when the natural cavities disappear, they form artificial ones, and fill them with a composition of resin, clay, &c. to make them appear black, but such fraud can be easily detected by observing whether there is a plate of the cortex striatus bordering the cavity, or not. This method, as well as observing the period at which foals cut or

* The enamel on the grinding surface of the incisores of the horse penetrates the body of the crown like the inverted finger of a glove. When the tooth has suffered by abrasion to a small extent, the fold of enamel forms an island of this substance enclosing a cavity, which is filled with crusta petrosa, and foreign substances from the food, and called by jockies the "mark." In aged horses, the incisores are worn below the "mark." Its disappearance in the different classes of the incisores are determined by the following periods: The cavity is obliterated in the first incisor at the sixth year, in the second incisor at the seventh year, and in the third incisor at the eighth year, in the lower jaw. The cavity remains longer in the upper jaw than that named as indicating their obliteration in the lower jaw.—*Ed.*

shed their teeth, must be rather fallacious; the first depending so much on the quality of their food as will presently be shown; and the second depending in a great measure on the constitution of the animal.

It is rather a curious circumstance that horses have forty teeth in both jaws, and mares have only thirty-six, the cuspidati commonly called tusks being wanting in the latter; though their rudiments are formed in the jaws, they seldom or never appear, and if they do, as the celebrated Buffon remarks, they are scarcely discernible.*

* The deciduous teeth of the horse are thirty-two, and are divided in number, as follows: Three incisores, one cuspidatus, and four molares on each side of a jaw. When all the teeth are developed in the horse, and second dentition, numbers forty, we have three incisores, one cuspidatus, three bicuspides, and three molares on each side of a jaw.

The deciduous teeth are erupted by the appearance, first, of the second molar between the second and fifth day after birth, and the third molar is seen a few days later, which is usually followed by the appearance of the central of first incisor at about the sixth day, and the second incisor appears between the twentieth and fortieth day, and about this time the first molar, or, more properly, the bicuspid appears, and, also, the fourth molar begins to cut the gum. About the sixth month the inferior lateral, or third incisor, makes its appearance with the small deciduous cuspidatus. This latter tooth is shed almost as soon as its contiguous incisor is fully in its place.

The first permanent molar appears between the eleventh and thirteenth months, and the second follows between the fourteenth and twentieth months. The first bicuspid appears from two to two and a half years after birth, the first incisor rises above the gum between the periods last named, and about three years the second bicuspid shows its crown above the gum by pushing out the third deciduous molar. The last or third bicuspid supplants the fourth deciduous molar about the fourth year, and the eruption of the last molar occurs a little anterior to this period. The second incisor appears between three and a half and four years, and the third incisor pushes out its predecessor at or about the fifth year, at which time the third molar has risen nearly on a level with the crowns of its neighbors. The small cuspidatus, contrary to the usual rule, follows the eruption of the second incisor, and its appearance indicates the age of four years. If the eruption of the central incisores have been accelerated by the premature removal of the deciduous teeth, the strong marks on the third incisores will indicate the fact.—*Ed.*

As the cow, sheep, &c. have no front teeth in the upper jaw, it was necessary that the edges of those in the under should be very sharp; the membranes of course do not pass down into the internal bony part of them, but they are formed as single teeth in general are.

Eustachius, although he did not investigate the subject fully, was aware of many circumstances relative to it, which I cannot pass over in silence. He says, "The situation of the human teeth is at the extreme edge of the circle of both jaws. In some of the brute creation, however, and in almost all fishes, their seat is in the palate, the tongue and even the stomach. Those animals which ruminate, we are told by all anatomists, have only an inferior range of teeth, in which, however, they are incorrect, for they do not want the entire of the upper teeth, but those only which should lie in front."* When speaking afterwards of ruminant animals, he describes that peculiarity of formation in their teeth, by which they become liable to contain heterogeneous particles, those especially of the food on which they are nourished.†

All the points of those teeth which we have been examining, had been at one time covered by the cortex striatus, and the plates of it were all at that time intimately connected, so that one continued line of it could be traced. It is evident, that in proportion as the cortex striatus is worn off these points, the bony matter must appear between its plates, therefore, in viewing the crown of an incisor, or its grinding surface, the crista petrosa is observed externally, then the cortex striatus, within which is the proper bony part, including again two plates of the cortex striatus, and in the middle of these the cavities filled by

* "Humanorum dentium sedes est extremus tantum utriusque maxillæ ambitus; quamquam multis belluis, sicut fere cunctis piscibus, palatum quoque ac lingua, et nonnullis aliis venter, pro sede sunt; et quæ ruminant, ut anatomici omnes scribunt, inferiorem tantum ordinem dentium habent, quod tamen non ita intelligendum est, ut quispiam hoc sermonis genere deceptus putet, eas superioribus dentibus prorsus carere, sed illis tantum, qui ad superius labrum pertinent."—*Opusc. de. Dent.* p. 9.

† Ibid. page 56.

the food, &c. so that this tooth consists of four different substances.

Mr. Hunter mentions in the description of plate xiv, fig. 19, Nat. History: "The enamel passes through the whole length of the tooth; the enamel is represented by the white lines which are penniform." It appears strange that Mr. Hunter should fall into such an error, nor can I conceive how he could, unless by a section where the plates of the cortex striatus approach so close to each other, that at first sight they appear penniform, but on closer inspection there are bony lamellæ observed between them, on which the fibres of the cortex striatus are arranged. Mr. Hunter's figure one would think had been drawn from an imaginary preparation, for in whatever direction a section was made, the appearances would have been different from what he has represented.

The windings, fibres and termination of the cortex striatus are accurately represented in fig. 7 and 11 of the same plate. The fibres pass upwards in an inclined direction towards the grinding surface, by which means the entire fibre is not broken off at one time, and of course the teeth last longer than they otherwise would. When we split or break a tooth of these animals, a beautiful silvery line is observed at the junction of the cortex striatus and the bony part.

According as the grinding surface of these teeth is worn down, (by the addition of bony matter to their roots and filling up of the sockets,) they rise in proportion, and continue to rise until all the plates of the cortex striatus are worn away, and even the roots. Sometimes they wear or are rubbed away very irregularly; I have seen an instance where a middle grinder of the upper jaw was protruded near an inch lower than any of the others, and had worked a groove for itself between the lower teeth. I have several instances in my possession less striking, all of which must have been very troublesome and detrimental to the poor beasts, and might, probably, have been prevented by a judicious operation.

With respect to the connection of the temporary and permanent teeth, I have found it in all animals I have examined, simi-

lar to that already mentioned as subsisting between those of the human.

Those animals that make use of their teeth as edged tools for cutting or scraping very hard bodies, such as the squirrel, rat, &c. are supplied with two incisores in each jaw, most admirably adapted for these purposes. As the under incisores are principally made use of, they are nearly twice as long as those of the upper: and, indeed, they are much longer than *a priori* I could have imagined, for they occupy the greater part of the jaw from the symphysis to the roots of the coronoid processes. In the under jaw of the squirrel, for instance, the incisores form almost a semicircle, and the grinders are situated within the segment of the circle. In the upper jaw they form a segment of a much smaller circle, and do not extend even so far as the anterior grinder.

The bodies of their grinders are covered by the cortex striatus; but it is deposited only on the convex surface of the incisores, so that the extremity with which they gnaw consists entirely of the cortex striatus. The flatted sides and concave surface are bone, in order that the external membrane might adhere to it and nourish the tooth, and also the bone being much softer than the cortex striatus, it is more easily worn down, by which means the cortex striatus is always prominent and retains a most acute edge. The edge itself, hard as it is, is constantly wearing away; but in proportion to its waste, the tooth is protruded by the addition of new ossific matter to its base, and the curve of the tooth is such that the edge of it always preserves exactly the same situation with respect to the upper teeth.

By the curved form the teeth acquire additional strength and are less liable to be broken than they otherwise would be. The squirrel I have just now spoken of, was domesticated, and used to amuse himself in chewing ivory which happened to be inlaid in some pieces of furniture.

The structure and formation of the incisores of the beaver are precisely similar to those of the squirrel and rat, and the color of the cortex striatus is likewise nearly similar, being an

orange or deep yellow. But there is a marked difference between the formation of their grinders, for, as I just now mentioned, those of the squirrel and rat are covered by the cortex striatus, but in the beaver it passes in a very convoluted manner round the bony part, as in the under grinders of the horse, so that when the upper part of the tooth is slightly worn down, one continued line of the cortex striatus can be traced. Sometimes, however, an additional point is observed unconnected with the line of the cortex striatus on the surface. The crusta petrosa fills up the external spaces left by the windings of the cortex striatus. This structure is admirably contrived and fitted to the purposes of the animal; for its food, (as Buffon mentions) being principally the branches of trees, &c. it could not otherwise grind it sufficiently; and to supply the consequent waste of the upper surface of the tooth, new ossific matter is continually adding to the base, which appears hollow and convoluted, without any appearance of roots being formed, which probably never are formed. We can easily conceive how they can cut down large trees, as mentioned by most historians, with such powerful instruments as their incisores.

The incisores and grinders of the rabbit and hare, are formed in a similar manner to those of the beaver, but the incisores, even in the under jaw, do not extend further back than the anterior grinder, and although the cortex striatus is similarly situated on them, it is of a different color, being white. It is worth observing, that in these animals (scil. the rabbit and hare) there are two small teeth situated at the internal part of the incisores, both in the upper and under jaw which scarcely appear above the level of the gum.

From the foregoing observations, as well as many others, it appears that the incisores of all such animals are never shed,* but augment in proportion to the increased size of their jaws. Hence arise the various breadth and curvature of these teeth at

* This does not hold good in the strictest language of dental comparative anatomy. The hare and rabbit which have developed thirty-six teeth, have only twenty-eight permanent teeth, there being six molares and two incisores that are deciduous teeth.—*Ed.*

different periods, and, probably, the protrusion of the tooth is owing to the continued growth of the bony matter from the surface or membrane of the pulp. Also, on the peculiar curvature the safety of the softer or growing parts depends, the pressure being confined to the prominent part of the tooth near the anterior part of the jaw, or towards the middle of the curve.

I have observed in all cases where a great portion of the cortex striatus was contained in the socket, and where the crusta petrosa would have been rather an inconvenience, portions of the bony part left without a covering of the cortex striatus, in order that the tooth might be nourished, and that part only covered by it which was intended for use, or exposed to injury. In some animals the crusta petrosa alone is deposited on their teeth, such as the spermaceti whale, whose teeth are confined to the lower jaw.

I have observed a very beautiful contrivance, with respect to the different ranges of teeth with which some genera of fish are provided, for instance the skate, in one species of which the teeth are spear-pointed, and their points turned towards the throat: their chief use seems to be, to enable the animal to retain its prey, or to crack the shells of lobsters, crabs, &c. which are probably its chief food. Although their teeth are covered by a very hard cortex striatus, they are, nevertheless, liable to be broken or worn down, by the shells of the animals they make use of. Nature, however, has wisely guarded against premature old age, by continually forming several ranges of teeth, so that as one or more of the front ranges are destroyed or naturally shed, the lower ranges advance forward and supply their place. How this circumstance happens I will now endeavor to explain: their teeth are not fixed in bony sockets, but attached to a cartilaginous or ligamentous matter which rests on the jaw. Each tooth has two processes or roots, and each root has a deep furrow near the neck, by which means it is more firmly connected, and as the front ranges are shed, the cartilaginous matter is by some process in the economy of the animal drawn forward, and with it the teeth, new ranges still continue to form, I may say *ad infinitum*, while the same process continues to take place.

A contrivance somewhat similar is observed in the common shark, whose teeth are spear-shaped, serrated at their edges and covered by a cortex striatus as hard as that of the former animals. These animals are said to live to a very great age, and from the nature of their food, as well as the accidents they are exposed to, their teeth are constantly in danger of being broken or torn away ; to guard therefore against such prejudicial effects, several ranges of them are formed and constantly forming. The upper range is placed nearly perpendicular on the margin of the jaw, the under ranges are regularly disposed quite flat one over the other, and their points are turned in an opposite direction to those on the margin. When therefore one tooth or range of teeth is shed or torn away, the tooth or range of teeth immediately underneath begins to turn up and pass into the place of the former.

These teeth are inserted in the cartilaginous matter of the jaw, as in the skate, and are so firmly fixed in it, that the animal has not power to move them at pleasure, as was formerly supposed. The number of ranges does not seem determinate, and the under ones are quite imperfect, the earthy matter of the cortex striatus being soft on them, but they gradually become more and more perfect towards the upper range. Their connecting membranes are similar to those observed in the human body, for the membranes pass down from the upper range which is forming to the second, from the second to the third, from the third to the fourth, and so on to the fifth, sixth, or seventh.

The same appearances may be observed in the angel fish, which was said to have had but four rows of teeth, but on cutting open the membranes, I found five or six of them.

Some months after I had written this chapter of my thesis, and mentioned the observations contained in it to many of my friends in Edinburgh, Mr. Robert Jameson was kind enough to send me a translation from the Italian of the Abbe Spallanzani's travels he received from London. In this work I was very much pleased to find many remarks by the Abbe and other authors, in support of my opinions.* He says, "we learn from

* Vol. iv. page 358.

Steno, that in the *squalus carcharias* (the shark) the inner (rows of the teeth) are bent downwards, and are so enclosed in the soft and fungous flesh of the gums, that unless the latter be cut away, they are not visible. For what use the teeth thus bent were intended by nature I cannot discover; since they are so buried within the flesh, that they cannot serve for grinding their food. The teeth in the first row may, perhaps, be designed to prevent the prey from escaping, or to divide it when too large to be received into the stomach; but why the others were formed I do not see, unless we say, that they have been produced by the necessary action of matter.”* The Abbe says, page 359: “But Herissant was of a different opinion. He found, after a very careful examination of several jaws of sharks, that the teeth, more or less covered with flesh, are teeth of reserve, to supply the place of those of the first row should they chance to be lost; in which case, these which lie below, rise out of the fungous flesh, and take the place of those that are wanting.”† “From the examination of several sharks’ jaws, I was now satisfied that the teeth of the second row, which are bent towards the throat, are not merely ‘produced by the necessary action of matter,’ as Steno has suggested, but designed by nature to supply the place of those of the first row, when they may chance to be lost; as was first discovered by Herissant; and I flatter myself I am the first who, since he wrote, has confirmed his ingenious and noble observation.”‡ After these remarks it appears rather strange that the Abbe Spallanzani should doubt, that the teeth of every species of *shark* were intended to alter their situation, according as the exigencies of the animal

* “Interiores (ordines dentium) inferiora versus recurvati, gingivarum molli et fungosa carne ita delitescabant clausi, ut non nisi resectis gingivis in conspectum prodirent. Cui usui dentes ita incurvatos natura destinavit, non perspicio, cum, carnes intra sepulti, escæ comminuendæ nullâ ratione potuerint inservire. Retinendæ prædæ, ne diffugiat, forsitan at diffringendæ majori, quam quæ ventrem subire possit, primi ordinis inserviunt: reliqui verò, nisi materiæ necessitate facti, non video cujus gratiâ sint consecuti.”

† Mem. de l’Acad. Roy. 1749.

‡ Page 363 and 364.

required. In describing the jaws of a shark, which he calls the squalus of Messina, he observes :* “One of the largest teeth in the first row is wanting, being entirely detached from the jaw. This loss could not have been recent, when the fifth was taken, as the fungous flesh had formed a scar over the place it had occupied, producing an angular elevation of some thickness. If, therefore, the second row of these teeth, and the same may be said of the other lower rows, had been designed by nature to supply the deficiencies that might happen in the first, it is evident that the tooth below would have occupied the place of the tooth wanting, or at least would have raised itself up and approached nearer to it. The fact, however, is, that this tooth, which we might have supposed to be formed as a substitute, is by no means such, but still continues in the same position with the others, and covered in the same manner with the fungous flesh.” It is very obvious from the Abbe’s remarks, that the tooth he alludes to was not perfect, being covered by its proper membranes, and of course at this period could have no tendency to rise or turn upwards ; but most undoubtedly, if it had arrived at perfection, it would have passed into the place of the former. Surely if one of the temporary teeth of a child was prematurely taken out, the permanent tooth underneath would not immediately rise up and supply its place.

A very singular contrivance I have observed with respect to the articulation of the teeth in the *lopius piscatorius*, commonly called by fishermen the sea-devil. The points of all the teeth are turned towards the throat, and each of them is joined at the internal part to an elastic cartilaginous or horny substance, which allows them to yield to the slightest external pressure, so that they afford no resistance to the animals it allures by its playfulness to enter its mouth, but the moment the external pressure is removed, the elastic springs react and press the teeth back into their original situation. The external part of the teeth form a kind of fulcrum on the jaw, and resist the pressure from the internal part so strongly, that I could not force

one of them out of its situation. The teeth placed in the stomach of this creature are similarly constructed, in order to prevent the escape of its prey.

CHAPTER IX.

OF SUPERNUMERARY TEETH, &c.

WHEN we consider the formation of the teeth, and the contiguity and intimate connexion subsisting between their rudiments, we cannot be surprised to meet with such frequent deformities and varieties as occur amongst them. Though deviations in the shape or size of their bodies seldom occur, yet their roots vary considerably, some being much larger than those commonly met with, others curved in different directions, or exceeding their usual number.

Eustachius, Jussieux, Fauchard and other writers mention some instances remarkable for the singular position of the teeth in the jaws. They also speak of having met with a few cases where two or three of the front teeth and as many even of the grinders were completely joined together by ossification. I have met with more than a dozen cases somewhat similar, for instance the bodies and roots of the lateral temporary incisores and cuspidati joined together, and among the permanent teeth, the middle and lateral incisores as also the lateral incisores and cuspidati. Here it is evident both pulps must have been contained in the same investing membrane or sac, for their ossification is in general so complete that one hole serves to both for the admission of vessels, &c. In those cases the body of each of the teeth so conjoined commonly retains its own appropriate form, though both are completely surrounded by the cortex striatus. Amongst the permanent teeth, however, I have met with one instance, where one of the middle and lateral incisores were so intimately united, that on viewing them externally they

appeared as one large middle incisor, no trace being left of their having originally two distinct bodies; but on the internal surface there is a very marked difference, and each retained nearly its proper shape. Excrescences of the cortex striatus are very seldom met with, one singular instance of it occurred to me, in a patient about 17 or 18 years of age. The right permanent cuspidatus in this person did not appear through the gum until the sixteenth year, on the side of it next the lateral incisor there was a bulbous protuberance of the cortex striatus, with a hollow or depression in the middle, this protuberance did not, however, extend to the apex of the tooth. Between the bulbous part, and the perfectly formed body of the tooth, there was also a deep groove, which perhaps retained part of the investing membrane longer than usual, or the external lamella of the membrane was not wasted, for there was a substance somewhat similar to the crusta petrosa of graminivorous animals deposited round the protuberance of the cortex striatus, and even on a considerable portion of the root. This substance stuck out and formed a sharp hook under the lip, which was very troublesome to the person, and as there was not sufficient room for the tooth in the arch of the jaw, it was of course advisable to have it removed. This is the only instance I have met with, or even heard of, where a crusta petrosa was deposited on a human tooth.

With respect to the uncommon situation of the teeth in the jaw, by far the most curious case is related by Albinus, of an adult in whom he found "two teeth, one on each side of the nose between it and the orbits of the eyes, enclosed in the roots of those processes, which extend from the maxillary bones to the eminence of the nose. They were long and remarkably thick, similar to the canine teeth and seem to have been these very teeth, which had not in this case appeared. But there were, besides these, other canine teeth, unusually small and short, placed in their proper sockets. The former seem therefore to have been the new canine which had not penetrated their sockets, on the contrary they were situated where the new ones usually are observed to be in children. But what is still more

strange, the points of their bodies were turned towards the eyes, as if they had been the new canine teeth inverted, convex on the posterior part, concave on the anterior, the reverse of what generally happens.”*

This case fully shows the great accuracy of Albinus, he did not mistake those singularly situated canini for supernumerary teeth, though he was aware that such frequently occur.

Mr. Hunter mentions his having met with a case somewhat similar, and gives “a sketch of the upper jaw of a child, where the cuspidatus was inverted, so that its point was turned up against the jaw, and the growing mouth of its cavity towards the gum.”

Amongst the temporary teeth, supernumerary ones are seldom observed. Dr. Hudson, however, has met with a few instances of this kind; they are much more frequently found amongst the permanent teeth, and especially in the upper jaw. Their shape in general resembles the cuspidati. He further observes, “they are not confined to the front of the mouth. I have found them in every part of the jaw, between the middle incisors, between the middle and lateral, between the lateral and cuspidati, &c. among the large grinders, on the outside or inside of them, and in the palate. I have also ten or twelve times found teeth beyond the *dentes sapientiae superiores*. They were all small, the enamelled part shaped like the adult grinders, but never with more than one fang. I call them second wisdom teeth, and always compliment my patient on the probability of possessing a double portion of sagacity.”

* “*Dentes duo inter nasum et orbes oculorum, dexter sinisterque, inclusi in radicibus processuum, quibus ossa maxillaria ad eminentem nasum pertinent. Longi sunt, crassitudinis insignis; similes maxime caninis, ut videri possint illi ipsi esse, non nati. At aderant præterea canini, præter consuetudinem parvi, et breves, suis infixi alveolis. Itaque videntur esse canini novi, qui non eruperint: utpote ibi loci collocati, ubi sunt novi illi in infantibus. Sed, quod miremur, sursum directi, tanquam si sint canini novi inversi. Et ita quoque formati sunt, ut, contra quam alii, à posteriore parte gibbi, ab anteriore sinuati sint, &c.*” Acad. Annotat. lib. i. p. 54.

How supernumerary teeth are formed we can easily conceive, but how teeth could be inverted as Albinus and Mr. Hunter have shown, is much more difficult to be accounted for. I have sometimes observed a supernumerary tooth, firmly attached to a grinder; Fauchard has noticed similar appearances and also mentions his having met with two grinders joined together, and a supernumerary tooth likewise connected with them. However, I do not think it necessary to dwell on this subject, particularly as it is a subject of curiosity more than of importance.

CHAPTER X.

OF THE VESSELS AND NERVES OF THE TEETH.

HAVING repeatedly injected and examined the jaws of young subjects, I observed blood vessels passing from the gum to the membranes destined to form the cortex striatus. It was natural enough then to conclude, that, as the investing membranes were derived from the gum, their nourishment too did originate from the same source, and that the use of the vessels which entered the proper foramina of the jaws, was only to form the pulp and bony part of the tooth. Further consideration of the subject, however, urged me to relinquish this opinion: it would by no means hold good on comparing it with what takes place in the jaws of large animals, for (as mentioned in chapter eight,) the cortex striatus continues to be formed on the external plates of their teeth even after the upper part of them has appeared through the gum.

As frequent opportunity occurred in the course of this essay to mention the vessels and nerves of the teeth, I would not have allotted them a distinct chapter, were it not that Mr. Hunter asserts that the teeth are nearly inorganic, and also that "we can actually transplant a tooth from one person to another."*

* Nat. Hist. p. 38 and 126. See also part 2d, pp. 94, 95, &c.

Although transplanting teeth was for some time practised, yet the dreadful consequences which so frequently ensued, as well as the bad success which commonly attended this operation, induced its most strenuous advocates (I trust forever) to lay it aside.

Mr. Hunter in support of his doctrine, asserts: "He could never trace the nerves distinctly even to the beginning of the cavity."* Yet Eustachius seems to have been much more fortunate in his dissections of man as well as other animals, which appears from the following quotation: "When we pass from the grinders to the small teeth, the nerve with its concomitant artery is divided into two branches, one of which passes out through the hole in the jaw near the lower lip; the other branch proceeds on to the roots of the incisores and sends to each a twig, one portion of which is expanded on the external membrane of the root, but the other, and that the most delicate, passes into the internal cavity. This fact, indeed, can be easily observed even in the human body by those who are engaged in accurate dissections. But it is truly wonderful and seems almost inconsistent with the laws of nature, that the incisores and canine teeth, which are small and have only one root, possess large and conspicuous branches of nerves and vessels, whilst the grinders, which are much larger and have three and sometimes four roots, are supplied by branches proceeding to each root nearly as small as hairs."† Dr. Monro has several preparations in his museum,

* Nat. Hist. p. 42.

† "Postquam vero a molaribus ad minores dentes descensum est, nervus cum arteria, quæ illum comitatur, bipartito scinditur, cujus pars una per foramen eo loco sculptum, ad labium inferius emergit; altera ad radices incisorum tendit, distributoque cuique ipsorum surculo, una portione sui cum exteriora radicum parte jungitur; altera autem, eaque tenuissima, sinum dentium penetrat; quod quidem etiam in homine ab his qui sectionem docte et accurate tractant, cerni non difficulter potest. Sed mirum profecto est, et naturæ æquitati parum decens videtur, incisores et caninos dentes, parvos unaque radice infixos, ejusmodi nervorum ac vasorum surculos magnos et conspicuos obtinere, patentique, via ad insertionem accedere: molares vero, eis longe majores, tribusque et interdum etiam quatuor radicibus præditos, eosdem surculos, qui bifariam, trifariamve, ac etiam quadrifariam scindi debent, capillorum modo tenues habere, obscurissimoque itinere incedere." *Opuscul. de Dentib.* p. 63.

in which the nerves and vessels were traced by him into the roots of the teeth, and also into the pulp.

Mr. Hunter observes:* “A strong circumstance in support of the teeth having no circulation in them, is that they never change by age, and seem never to undergo any alteration, when completely formed, but by abrasion;† they do not grow softer, like the other bones, as we find in some cases, where the whole earthy matter of the bones has been taken into the constitution. From the foregoing experiments it would seem that the teeth are without absorbents as well as other vessels, and are to be considered as extraneous bodies, with respect to a circulation through their substance.” These remarks of Mr. Hunter’s are by no means just, for the bony part of a tooth undergoes changes by age, as well as any other part of the body. Indeed, if by chance the vessels which enter the roots and are distributed on the pulp be torn, or destroyed, the body of the tooth becomes discolored, sometimes nearly black, the external membrane which surrounds the roots not being sufficient to supply it with nourishment, so that the bony part acts as a foil to the cortex striatus. I have frequently observed their roots changed nearly to a cartilaginous substance and rendered perfectly transparent by the absorption of the bony matter. The roots of the grinders have been so frequently observed joined together by exostosis, that its occurrence was well known to Eustachius, nay even to Hippocrates.‡ However, an incontestable proof of the presence of vessels both circulatory and absorbent and consequently of nerves, may be deduced from the progressive or continued growth of the incisores in the squirrel tribe, and the coloring of the teeth of all animals from feeding on food mixed with madder, and the subsequent loss of the acquired color from discontinuing the use of madder: this circumstance shall be referred to in the next chapter.

In one of my preparations I observed that the artery and nerve separated, soon after their entrance into the common foramen of the jaw, the artery passing in a distinct groove near the

* Nat. Hist. p. 39. † The density of teeth greatly influenced by age.—*Ed.*

‡ Opuscul, de Dentib. p. 97.

roots of the teeth, and sending off a small branch in the course of the nerve to nourish it, so that in this case they could not impede each other's action.*

CHAPTER XI.

OF THE CORTEX STRIATUS.

I HAVE frequently demonstrated in the course of this essay, that (in all the animals we have been examining, as well as man) the earthy matter of the cortex striatus was at first deposited by the investing membrane, in a soft and moist state, on the external bony lamella of a tooth.† In this condition, when allowed to dry on the human tooth, it cracks, and assumes a yellowish white color, adheres to the tongue, feels rough and stains the fingers slightly when rubbed between them. It continues seemingly without any change of texture until it has acquired its full degree of thickness, when the vessels of the investing membrane assume a different mode of action, from what they had hitherto done and probably pour out a fluid, which disposes the earthy particles to arrange in such or-

* It would hardly appear necessary for us to add any thing to the above, were it not that some recent writers have intimated, that all appearance of vascularity of dental bone is deceptive.

None that have examined carefully the structure of the teeth, aided by the recent microscopic discoveries, can doubt the vascularity of these organs.

Granting the argument (which is not true) that no vessels can be distinguished in the denture, it would still fail to establish its non-vascularity. The vessels entering the synovial membranes and inter-articular cartilages, cannot be traced; but that such do take on inflammation and other characteristics peculiar only to vascular bodies, while laboring under disease, is familiar to every pathologist.—*Ed.*

† The manner and source from which the cortex striatus is secreted and deposited, is explained in note on page 23.—*Ed.*

der, as by virtue of their mutual attraction to form themselves into fibres of an angular shape, from whose apposition arises a mass of a determinate figure, the surface of which becomes white, shining, hard and beautifully polished.

On breaking a perfect tooth, we observe the cortex striatus composed of innumerable fibres, disposed upon the bony part of the tooth in the same manner as those of the articular cartilages over the extremity of the bone in the joint of the thigh, or any of the other very movable joints; or they are crystallized exactly in a similar manner to the striated snow white zinc spar of Mr. Kirwan.* These fibres are first formed or crystallized on the points or edges of the tooth, and they proceed very slowly, range after range, towards the neck where they terminate.†

The accuracy of Mr. De la Hire's observations, respecting the arrangement of the fibres of the cortex striatus upon the body of the tooth, justifies their insertion. He says, "It is composed of numberless small fibres, which are attached to the internal part of the tooth by their roots, nearly as the nails and horns are to the parts with which they are connected. We can see without difficulty this structure when a tooth is broken, and we observe that the fibres which arise from that part of the tooth next the gum, are there very much inclined, but they are placed perpendicular on its base; by which means they resist in a greater degree without injury the actions to which they are exposed.‡

* Kirwan's Mineralogy, vol. ii, p. 236.

† The cortex striatus consists like the other dental substances, of earthy matter arranged by organic forces in an animal matrix, but differing by the presence of a far greater proportion of the mineral ingredients than is found in other parts of dental substance, and which are deposited in prismatic layers.—Ed.

‡ "Qu'elle est composée d'une infinité de petits filets, qui sont attachez sur la partie interne de la dent par leurs racines, à peu près come les ongles et les cornes le sont aux parties où elles s'attachent. On voit très facilement, cette composition dans une dent rompuë, où l'on remarque que tous ces filets, qui prennent leur origine vers la partie de la dent qui touche la gencive, sont fort inclinez à cette partie, et presque perpendicu-

Many authors suppose that after the tooth has appeared through the gum, the cortex striatus continues to increase in thickness and hardness, and that it becomes more and more perfect and beautiful until a certain period of life, at which period *only* it begins to wear away. Fauchard says, "This substance which we call the enamel, is formed previous to the appearance of the tooth, but it strengthens and becomes more beautiful, until the age of twenty years or thereabout; after which period it begins to wear away by the continual friction."* The many observations, however, already made on the cortex striatus, and also those which are immediately to follow, will induce us to form a very different opinion from Fauchard and others.

I have shown in chapter iv, that Mr. Hunter's theory respecting the formation of the cortex striatus is not just, for he supposed that it was formed both by a pulp and capsula. Now the cortex striatus according to my observations is deposited and formed by a membrane alone, and I have repeatedly mentioned that when it assumed the crystalline form, the membrane was wasted. It has been also demonstrated in the human tooth, as well as in those of animals, that, even where the investing membrane was not wasted, the cortex striatus, once formed, did not receive the slightest accretion of a similar substance, but that the membrane assumed a different mode of action and deposited a crusta petrosa on its surface, as is so generally observed in graminivorous animals. From thence and many other observations and experiments, I conclude, that, when once a tooth penetrates the gum, the cortex striatus is then as hard and perfect on it, as it can be at any future period of life, nor does it even after that period receive the slightest

lares sur la base de la dent: par ce moyen ces filets résistent davantage à l'effort qu'ils sont obligés de faire en cet endroit." *Mathém. et Memb. de l'Acad. Roy. des Sciences. Mem. de l'Acad. de 1699.*

* "Cette substance que l'on nomme émail, se forme avant la sortie de la dent, se fortifie et s'embellit jusqu'à l'âge d'environ vingt ans; après lequel tems cet émail commence à s'user par le frottement continu." *Le Chirurgien Dentiste, tom. i, p. 24.*

degree of nutrition; indeed it does not seem to require it, for I have frequently observed in old church yards the cortex striatus quite perfect, although the bony part had entirely mouldered to dust. The appearance of the cortex striatus, however, is much influenced by the state of the bony part underneath, the color of which in a certain degree it partakes of, so that it seems to improve until a certain period of life, though in reality it does not; and as I just now mentioned, it does not increase either in thickness or hardness after it has appeared through the gum.

The cortex striatus is perfectly formed in a much shorter space of time on some teeth than on others; the slow progress of it, however, does not seem to have much influence with respect to its perfection, for, it is frequently observed more perfect and beautiful on those teeth which require only twelve or fourteen months for their formation, than on those which require as many years, scil. the temporary incisores and wisdom teeth. In general it seems to require about six or eight years, from the time it commences to crystallize on the points of the permanent teeth, until it is perfectly formed around their bodies.

From the foregoing observations we can readily understand, how defects or derangements in the constitution, or the many changes which take place in it, during the periods we have mentioned, may, at times, totally impede the formation of the cortex striatus, or render it susceptible of various stages or degrees of perfection. Now, as the corresponding teeth in both jaws (for example, the anterior permanent grinders) are formed at the same time, if there should have been any derangement in the system during the period of their formation, we find their cortex striatus imperfectly formed, and, of course, the foundation of their decay laid. But as a considerable period elapses between their formation and that of the middle grinders, the constitution often acquires such vigor in this interval, that the middle ones are frequently observed perfect, whilst the anterior are rotten.

I have many times met with teeth on whose points or edges the cortex striatus was perfectly formed, but immediately under the perfect fibres it became imperfectly crystallized, of a yel-

lowish color and remarkably indented or pitted. These pits frequently extend over a great portion of the body of the tooth and the cortex striatus becomes again perfect towards the neck; they are usually situated on the upper surface and sides of a grinder particularly at the junction of the shells.

There is a permanent incisor amongst my preparations, the upper part of the cortex striatus on the body of which was imperfectly formed, being soft, pitted, and of a dark brown color; a few perfect fibres, however, were formed near the neck, and instead of the pulp contracting at this part as it usually does, it extended considerably beyond the body of it, as if nature endeavored at this period to form it anew.

An ingenious surgeon dentist of Liverpool (Mr. Wooffendale) in endeavoring to account for these pits, makes use of the following observations:* "I have been at some pains, and I believe my endeavors have not been in vain, to ascertain a cause for these appearances," which he entirely attributes to the small pox, but when his theory begins to fail, he says, "I have frequently seen these marks on both the first and second sets of teeth, which causes me to suspect such children have had the small pox twice."

In most of the cases I have just now mentioned, there seems to have been some defect in the constitution, with respect to depositing the ossific matter at certain periods; but in other cases and those which are by far the most frequent, there seems to have been a want of that particular change which disposes the earthy particles to crystallize.† Many times have I seen the anterior permanent grinders as soon as they appeared through the gum, with almost the entire earthy matter of their cortex striatus perfectly soft and opaque, most commonly, however, it remains soft at the interstices or junction of their shells,

* Observations on the Teeth, pages 34 and 35.

† When the functional operations of the body are disturbed during the formation of the teeth sufficiently to disturb the action of the secretory system, and the vessels for the deposition of the earthy particles of the cortex striatus suspend their action, the teeth will present to the eye the appearance described in the text.—*Ed.*

and at the termination of the cortex striatus on the neck of the tooth. I have, also, frequently observed a thin hard scale of the cortex striatus on the surface of a grinder, which being broken by some accident, the internal part of it appeared quite soft; similar appearances (though less frequent) I have observed on all the teeth. But in the different tribes of animals we have been examining, some of whose teeth are formed in a much shorter space of time than the human, I have not as yet seen a single instance where the cortex striatus was imperfectly formed.

Although a variety of experiments have been made on young animals, in which their bones were deeply tinged of a red color, by mixing madder with their food, I do not think any of them as yet prove, that the coloring matter was equally communicated to the cortex striatus. Mr. Hunter says,* “In all these experiments I never could observe, that the enamel was in the least tinged, either in the growing or formed tooth. This looks as if the enamel were the earth more fully depurated or strained off from the common juices in such a manner, as not to allow the gross particles of madder to pass.”

Other physiologists, however, assert the very reverse; and I have frequently seen teeth the cortex striatus of which was said to be highly tinged by the animal feeding on food mixed with madder, but on carefully examining them, I found, that the external surface only was highly stained by grinding the food, for, when broken across, the internal part of the cortex striatus was scarcely tinged, and also the external color was easily washed off. I have, however, a very beautiful specimen of the grinder of a young pig which had not appeared through the gum, the bony part of which is tinged of a most brilliant red color, but the cortex striatus, although tinged, is but slightly so in comparison with the bony part.

Mr. Hunter's experiments and observations on this subject, I have now shown are not just, particularly where he says, “the enamel takes no tinge from feeding with madder, even in the youngest animals.”

* Nat. Hist. of the Teeth, p. 35.

To ascertain whether the cortex striatus would take as deep a tinge as the bony part, I instituted the following experiment, which did not altogether answer my expectation; however, it establishes one fact, viz. "that the coloring matter of madder can be communicated to the *fœtus in utero*." I procured a female rabbit three or four days after pregnancy, and fed her regularly on food mixed with madder; about twenty-eight days after she brought forth six young ones; one of these I immediately deprived of life, and found its bones slightly tinged of a red color. Another of them being suckled by the mother for about twenty days, was then deprived of life, its bones were much more deeply tinged than the bones of the first. The bones of a third being fed on the food mixed with madder, for ten or twelve days after, were much more brilliantly tinged than any of the former. The teeth of all these animals were tinged, but whether the cortex striatus was equally stained with the bone, or whether the color of the bone shone through the cortex striatus (which in the rabbit is remarkably thin) I cannot positively affirm.

At present, however, I am conducting a similar experiment on a pig, in order to ascertain this point, as well as many others: the cortex striatus being much thicker on this animal's teeth than on the former, and, also, being much more easily fed: the *progress of which* I intend to make public.

Dr. Rutherford, in his Lectures on Botany, when speaking of madder, introduced some beautiful and interesting experiments he had made on this subject, extracts from which he was kind enough to allow me to insert. He says, "It has been long known that if madder be mixed with the food of living animals, their bones presently acquire a red color. This was accidentally first discovered in some hogs which had been fed in a dyer's yard upon bran that had previously been employed to discharge the loose and superfluous coloring matter from calico or cotton cloth recently dyed with madder.

In these the bones were quite of a full red, while the cartilages and the meat, fat; in general, all the soft parts had no particular tinge, or remained entirely of the usual appearance.

A fact so unexpected immediately attracted the attention of the observer Mr. Belchier : and many experiments were made by him and by M. Du Hamel, to investigate the subject. It soon appeared, that only the proper bony part received the tinge, the soft parts, even the gelatinous and cartilaginous matters, in which the bones themselves were formed, remaining untinged, when the proper bony fibres had already acquired a deep red color. That the younger the animal was, the more quickly was the change produced : in a young pigeon some change was observed within twenty-four hours, and within three days all the bones were of a scarlet color. That the bones were unequally tinged, the harder the more deeply, the middle therefore of the long bones, and the bony part of the teeth (although the enamel remained quite white) the most deeply of all. Sometimes, however, irregularly even in young animals, spots appearing in them much deeper than the general tint of the whole, in old animals, again several faint spots often appeared on a darker ground : or even spots of different colors or hues, that by discontinuing the use of the madder, the red color gradually disappeared or was discharged and the bones re-assumed their natural appearance.

Subsequent experiments have shown that the fluids are also tinged by madder, the serum and milk especially. M. Du Hamel immediately concluded that it was the nutritious matter of the bone only, which conveyed the coloring matter ; and others, following his idea, have justly observed, that this is deposited along with the earth of the bone. But how this comes to pass, why the bones receive a much deeper tinge, than any other parts of the body, has not, so far as I know, as yet been satisfactorily explained. Though M. Du Hamel approached nearly the true explanation, when he illustrated the subject by the phenomena observed in dyeing cloth with madder.

We have in the fact before us, a beautiful example of a particular case of chemical attraction ; such as, in numberless instances, is observed to take place betwixt the coloring particles of both animal and vegetable substances and various other bodies ; especially earths or earthy salts, and oxides of metals.

So strong is the affinity of the coloring matter to these bodies, that it is frequently observed to quit the menstruum in which it may chance to be dissolved, to unite with them; they, in consequence of its union, acquiring a particular tinge, while the menstruum is proportionally deprived of color. Or, when both happen to be dissolved in the same menstruum, if, by any means, these bodies are disengaged, become insoluble in the menstruum, and are precipitated from it, the coloring matter likewise falls down along with them, or in combination with them. From this principle, this mutual attraction, is deduced the various use of these bodies, as mordents, as they are called, intermedia, or means for fixing the colors in dyeing, and staining thread, or cloth, whether it be composed of animal or vegetable materials.

It is often to be observed that the coloring matters, which are commonly employed as dye-stuffs, have hardly any conspicuous affinity with pure animal or vegetables fibres, and that, though they seem to communicate a considerable tinge to these fibres, yet the color adheres only slightly to their surface, so that it can easily be washed or rubbed off again, thus leaving these fibres very nearly of their original complexion. But if the fibres be previously impregnated with a proper mordent, by the interposition of this, and in consequence of the mutual affinity that subsists, both betwixt it and the coloring matters, and likewise betwixt it and the fibres, the coloring matter now attaches itself so strongly to these fibres, that they seem to become incorporated altogether, and the color communicated to the fibres is proportionally fixed and durable; and resists, unchanged, the action of various substances, by the application of which, it would have been otherwise greatly altered, or, perhaps, entirely discharged.

Upon the same principle depends the preparation of those pigments, known to painters by the name of lakes. These are truly precipitates of the coloring matter, in combination with various mordents as their bases. They are prepared by mixing together solutions of the mordent and coloring material: or dissolving both in the same menstruum, and

adding, if need be, such substances as shall effectuate their precipitation, or cause their separation from the menstruum. The color of the lake may frequently be changed at pleasure even while the same coloring material is employed, viz. by using different mordents, as the color is influenced by the nature of the particular mordent that is used, and the peculiar chemical action this may have upon the coloring matter.

The coloring of the bones of a living animal by the use of madder, is in every circumstance analogous to the preparation of these lakes. The coloring matter of the madder, passing unaltered through the digestive organs of the animal, enters the general mass of fluids, and is dissolved in the serum of the blood; to which, indeed, if it be in large proportion, it communicates a very sensibly red tinge. But there is always present in the blood, and in a state of solution in the serum, a quantity of the earthy matter of the bones, phosphate of lime, ready to be deposited, as the exigencies of the animal shall require. Now, the phosphate of lime is an excellent mordent to madder, has a strong affinity to it, and consequently is admirably fitted to afford a base to the coloring matter of it, and thus forms a lake. This is what actually takes place, whenever, in such circumstances, by a peculiar animal process, the matter (which probably serves to keep the phosphate in solution) being withdrawn, this concretes within the cellular texture, into the fibrous and solid matter of the bones; for at the instant of its losing its solubility, it powerfully attracts and combines with the coloring matter of the madder, that is present in the serum, communicating insolubility also to this coloring matter, and hence they both concrete together into a homogeneous mass, not white or colorless, as the pure earth of bones usually is, but tinged of a full crimson or carmine color.

That this is actually the case, may be shown by various experiments. Thus, if to an infusion of madder, in distilled water, be added a little of the muriate of lime, no change is perceived; but if to this mixture be a solution of the phosphate of soda, immediately a double elective attraction takes place: the muriatic acid, combining with the soda, remains suspended or

dissolved in the water; while the phosphoric acid, thus deprived of its soda, combines with the lime, which the muriatic acid had parted with, and forms phosphate of lime, or earth of bones. This substance being, however, insoluble in water, falls to the bottom: but having combined, at the instant of its formation, with the coloring matter of the madder, they fall down united into a crimson lake, precisely of the same tint with that of bones of young animals which have been fed with madder.

From this simple representation of the matter, we have a ready explication of every circumstance that has been remarked as extraordinary respecting this subject.

Why, e. g. the bones of young animals should be more quickly, and more deeply tinged than the bones of older animals. Because there is a more rapid deposition, and also more rapid change of earthy matter in the bones of young animals, though probably the earthy matter as it is deposited, is equally deeply tinged in old as in young animals, yet, in the latter, the color of it is less diluted by the intermixture of particles, which had concreated before the commencement of the experiment, and were consequently of the natural or white color. Why the harder parts of the bones are most deeply tinged, because a greater number of colored particles are compacted into the same space. Why sometimes a bone seems mottled or spotted, because, there had, probably, been some topical irregularity, respecting either the secretion of fresh bony matter, or absorption of what had formerly been deposited. Why the bones acquire a very deep tinge, when perhaps the serum of the blood has not acquired any sensible color from the madder. Because the fluids being in constant motion and the earthy matter being deposited very slowly, the nascent bone being continually washed, and for a considerable length of time, by the stream of serum, it attracts and combines with the coloring matter of all the serum, with which it chances to be washed, while it is in the act of concretion. Hence likewise appears, why the gelatinous and soft matters in which the bone itself forms should have no tinge, though the bony fibres acquire a very deep one; for even were these matters composed chiefly of the matter of bone, still this must

be in a state of solution, and in that state it cannot attract or cause any accumulation of the coloring matter or separation from the fluid in which it is dissolved. Why the enamel of the teeth receives no color, because in fact there is no change in that substance, with respect to either secretion or absorption after it is once formed.

But it by no means follows, that the enamel of the teeth may not acquire a tinge, in the same manner as the earth of bones, provided that the fluids of the body were sufficiently loaded with the coloring matter of madder, or other such tinging material, at the time that the enamel is secreted, or first assumes a concrete form; as in young animals while their teeth are just in a nascent or incipient state; or perhaps still better, in the foetus in utero, viz. by mixing the tinging materials plentifully with the food of the mother during her gestation.

But even though the enamel should acquire a tinge in such trials; it may well be, that this tinge shall be very different from that acquired at the same time by the bones: for as the structure and composition of the enamel is different from those of the fibrous or earthy part of the bones, it is likely that it may have a different effect in modifying the coloring matter of madder; both with respect to the particular tint or species of color, and the particular shade or intensity of it: just as we find, that with the same colored infusion, by employing different mordents or bases, various lakes may be obtained differing from one another in color, both in species and degree.

“The same observations may be made concerning the concreting particles of many other solids of the body. Those of the different solids may receive at the same time, each, according to its particular nature, a different hue. Or, perhaps, having no particular affinity with the coloring matter of madder, incapable, therefore, of acting as a mordent to it, may receive not the slightest tinge from it. It is to be understood that the solids here alluded to are those only which derive the firmness of their texture from the chemical concretion of particles deposited in them from the general mass of fluids. These particles must, therefore, be considered as absolutely lifeless and

inert, possessed of no qualities whatever but such as are competent to any inanimate matter. It is with these particles only that the coloring matter combines. These, then, are the only parts of an animal body which can be tinged or colored by the use of madder or any other such material. Hence it is not to be expected, that the living solids of the body, e. g. the brain or nerves, should ever receive the slightest tinge in such experiments, or even those that are formed by the coagulation of the coagulable parts contained in the fluids of the body.

“It is natural to suppose, that there may be many vegetable substances, which, like the roots of madder, are possessed of the quality of communicating a particular color to the bones of living animals: all that is required for producing this effect, is, that the coloring matter of these substances should be of such a nature, that it shall not be altered by the digestive powers of the stomach, shall enter the mass of fluids and be dissoluble in the serum of the blood, and that it shall have a strong chemical affinity with the earth of bones. Then we may reasonably conclude, that by the use of such substance, the bones will acquire the particular color the substance employed usually gives to other bodies, and we attain to almost absolute certainty in this matter, by such an experiment as that formerly taken notice of. Several such substances have already been discovered and their power ascertained, by direct experiments upon living animals, e. g. the roots of several species of the *galium asperula* and other plants of the same natural order with the *rubia*, all those like the *rubia* itself, give a red color to the bones. But there are, probably, many others, hitherto unascertained, which would give very different colors: or at least very different tints of red. Many plants are known to give a red color to the urine, e. g. beet root, fruit of the *opuntia* or Indian fig; many more communicate a yellow tinge to the urine, and, sometimes, a tinge of great brilliancy. A single dose of the root of rhubarb will frequently render the urine of a gold color. There can be little doubt that by the continued use of such plants, the bones would also acquire a bright yellow color. Perhaps some plants may be found abounding with a blue juice, of such chemical quali-

ties, as to enable it to tinge the bones of living animals of a blue color: an example, indeed, does not occur of one exactly fitted for this purpose, except, perhaps, the *genipa americana*, the pulp surrounding the seeds of which, is said to stain animal matters of an indelible blue: and this might, perhaps, resist the digestive processes going on in the stomach, and in this case would probably give a blue color to the bones. The juices or rinds of some other purple fruits may be possessed of such qualities, as several appear to pass through the intestinal canal without having undergone a very great change in respect of their color.”

I mentioned in my thesis, that the cortex striatus differed materially in its chemical qualities from the bony part of a tooth, being chiefly the carbonate of lime,* but did not introduce the few experiments I had an opportunity of making on it, thinking them by no means conclusive: I shall now, however, mention those which induced me to form this opinion. *Experiment 1.* I found that the cortex striatus was entirely soluble with effervescence in dilute nitric or muriatic acids. *Experiment 2.* When some of it was exposed to a heat of about twenty of Wedgewood for twenty-five minutes, it was reduced to a remarkably white powder: on throwing part of this into distilled water, a hissing noise was heard, and on adding a few drops of muriatic acid to it, a much slighter effervescence took place, than where the fresh cortex striatus had been made use of. This subject, however,

* The chemical constituents of the enamel, according to the analysis of Berzelius, shows the phosphate of lime as being the predominating mineral ingredient in its composition. He shows that in every 100 parts of enamel there is found,

Phosphate of lime,		85.3
Fluate of lime,		3.2
Carbonate of lime,		8.0
Phosphate of magnesia,		1.5
Soda and muriate of soda,		1.0
Animal matter and water,		1.0

100

The analytical result is different in different individuals, but in all cases, the predominance of the phosphate of lime over all other of its component parts is distinctly marked.—*Ed.*

has been since prosecuted with much greater judgment and accuracy by the truly scientific analyst, Mr. Charles Hatchett, and he was so very obliging as to repeat before me the experiments he had made on it, which were published in the Philosophical Transactions for the year 1799.*

By these I was at once convinced of the error I had fallen into, for although the cortex striatus contains a certain proportion of the carbonate of lime, it is chiefly composed of the phosphate; the precise proportions, however, have not been as yet ascertained, Mr. Hatchett's time not permitting him to make a complete analysis, his experiments are as follows: *Experiment 1.* "Some enamel, rasped into a fine powder, was put into a matrass, and, pure muriatic acid being added, the whole was suffered to remain without the application of heat during one hour; in the course of this time, the enamel was completely dissolved with a gentle effervescence.

"To this solution, some sulphuric acid was gradually added, till all precipitation had ceased: the precipitate was separated by a filter, and was found to be selenite, the filtrated liquor, by evaporation, afforded a small additional quantity of selenite, which was also separated; after which, the liquor being evaporated became thick and viscid. This, when diluted with water, precipitated lime from lime water, in the state of phosphate.

"To another portion, solution of acetite of lead was added, and caused an immediate precipitation of a white matter, which when dried and sprinkled on burning charcoal, produced a light and smell like phosphorus; it, moreover, was soluble in nitrous acid and was thus to be distinguished from muriate or sulphate of lead.

Experiment 2. "Some of the raspings of enamel were dissolved by digestion in nitric acid, and, when the solution had been diluted and filtrated, it was saturated with carbonate of ammoniac. The precipitate thus produced was collected and edulcorated in a filter. The small excess of carbonate of ammoniac, in the filtrated liquor, was saturated with acetous acid; after which, the phosphoric acid was precipitated, by solution

* See Mr. Home's Observations, &c. pp. 9 and 10.

of acetite of lead. Upon examining the first precipitate, or that produced by the carbonate of ammoniac, it was found, contrary to expectation, that it was still composed of lime, combined with a portion of phosphoric acid, instead of carbonic acid, which might have been supposed.

“To effect, therefore, a complete separation of the two ingredients, (lime and phosphoric acid,) acetous acid was poured on the precipitate, by which it was immediately dissolved. The whole of the phosphoric acid was then separated from this solution, by acetite of lead; after which, lest any lead should be present, the liquor was saturated with pure or caustic ammoniac, and the lead was separated by a filter: lastly, the lime which remained dissolved, was precipitated (in the state of carbonate) by carbonate of ammoniac.

“The enamel has been supposed, not a phosphate but a carbonate of lime. This error may have arisen from its solubility in acetous acid or distilled vinegar; but the effects of the acetous acid are, in every respect, the same on powdered bone as on the enamel. Consequently, when enamel, or bone, is put into a glass matrass containing acetous acid, placed in a sand bath, the portion which is dissolved, is not (as has been supposed) carbonate, but phosphate of lime; for, if to the filtrated solution, nitrate or acetite of lead is added, a precipitate is produced of phosphate of lead, in the same manner as when nitrate or acetite of lead is added to urine.”

Mr. Hatchett has made many other very interesting experiments and observations on shell and bone, &c. the results of which would be too numerous to insert, he, however, says,* that “the enamel appears only to be different from tooth or bone, by being destitute of cartilage, and by being principally formed of phosphate of lime cemented by gluten. The difference, in the latter case, seems to explain why the bones and teeth of animals fed on madder become red, when, at the same time, the like color is not communicated to the enamel; for it appears probable, that the cartilages which form the original structure of the

* Mr. Hatchett's Experiments, &c. p. 19. Philosophical Transactions for 1799.

teeth and bones, become the channels by which the tinging principle is communicated and diffused." Mr. Hatchett at this period had not seen Dr. Rutherford's experiments and observations on madder.

From the foregoing observations, it is perfectly evident, that the most simple and best prepared tooth powder, frequently applied to the teeth, must be injurious, as they all tend to wear away the cortex striatus. Even at present many people are not content with the use of tooth powder alone, but form it into a paste with syrup or honey, by which its action is much increased; such preparations certainly clean the teeth much sooner than the others, they also much sooner wear off the cortex striatus and destroy its beautiful polish which never after can be regained.

The tooth powders commonly sold consist in a great measure of cream of tartar, by the use of which I have seen the teeth completely deprived of their cortex striatus and the patients rendered quite miserable, for the bony part of the tooth in such cases becomes sensible to the slightest touch and also to the slightest change of temperature in the atmosphere or other fluids received into the mouth. Cream of tartar alone has been recommended by Mr. Hunter as a tooth powder, because, as he says, "at the same time that it acts mechanically, it has likewise a chemical power, and dissolves this adventitious matter."*

To ascertain the bad effects of cream of tartar as a tooth powder, I made the following simple experiment, which will at once explain how very detrimental the use of it must be, even in the smallest proportion. I placed a tooth in a solution of cream of tartar and water, and allowed it to remain in it for about twelve hours; when taken out, I observed that the surface of the cortex striatus was quite rough, and according as it became dry, it appeared sprinkled over with an immense number of small crystals though very few were observable on the root. The formation of these crystals can be easily accounted for: the acid of tartar has a greater affinity to calcareous earth than it has to the vegetable alkali with which it is combined in cream

* Nat. Hist. part ii, page 69.

of tartar, a double elective attraction of course takes place when a tooth is immersed in a solution of it, the acid of tartar combines with the lime and forms a salt nearly insoluble in water, and which is deposited in the form of crystals on the body of the tooth, whilst the other portions, scil. the vegetable alkali and phosphoric acid, &c. combine and remain dissolved in the mixture. Likewise, in cream of tartar, the vegetable alkali is supersaturated with the acid of tartar, so that even in powder and without a complete decomposition of it, we see how readily it may act as a solvent for the cortex striatus, which is seemingly the chief part acted on by it, the bony part as already mentioned being covered with scarcely any of the crystals. When a tooth is placed in dilute acid of tartar, the body of it becomes covered in the same space of time with much larger crystals.

A variety of essences and lotions are also recommended and sold for cleaning the teeth, many of which contain acids, and though perhaps but a very small quantity, yet, when constantly applied, they undoubtedly must dissolve and destroy the cortex striatus, &c. I shall terminate this chapter by seriously recommending parents to have their children's teeth and gums in particular, brushed and washed with a soft brush and water at least morning and evening, commencing at the period when the temporary teeth are complete, that is, in general about the second year. This early attention will render the operation habitual, and I am fully convinced the benefits to be derived from it are almost incalculable.

If their teeth and gums are diseased, I need not add that medical assistance should be immediately procured, for I have met several cases, in which (by neglecting to keep the gums of children in good order) some of the permanent teeth have been cast off with the temporary; one case in particular occurred to me, of a child about three years old, in which the four permanent incisores of the under jaw and a considerable portion of the jaw itself had been sloughed off, by not attending to the child's mouth whilst it was laboring under, and after the recovery of the confluent small pox; this child, of course, will be disfigured through life.

CHAPTER XII.

OF DENTITION.

THE human body, on account of the very great delicacy of its structure, is at all periods of life subjected to a variety of complaints; but by reason of the extraordinary degree of irritability during infancy, the body is then peculiarly susceptible of morbid impressions, from even the slightest cause, especially during the first year or two after birth. As some reason must be assigned for the various affections which then occur, and as most of the temporary teeth appear during this period, empirics (to screen their ignorance) have hit on that theory most likely of all others to be received by the mass of the people, viz. that these complaints were owing to the irritation, occasioned by the violent efforts the teeth make in bursting and tearing through the gums. This opinion has been handed down from one generation to another, and we find the ancient as well as most of the modern physicians contenting themselves with the old adage, that, "what every one says must be true," without thinking for themselves, or accurately examining the appearances and state of the parts, which alone could be acquired by dissection.

It would be both tedious and uninteresting to the reader to collect and arrange the hypothetical remarks diffused through numberless volumes in order to support this doctrine; a few of their observations will therefore be sufficient to show how discordant they are one with the other, and also the very fallacious inductions they deduced from them. Hippocrates supposed the most violent affections arose from the cutting of the canine teeth.* Boerhaave on the other hand supposed they arose from the appearance of all the sharp teeth, scil. the incisores;† but his commentator, Van Swieten, differs with him and gives a most plausible reason why some teeth work their passage through

* Aphor. 25. sect. 3.

† Aphor. sect. 1374.

the gum with much less difficulty than others. He says, "As all the foregoing disorders proceed from the stretching, puncturing, and lacerating the nervous and bloody gums, it is evident, therefore, that the worst symptoms are to be dreaded when the canine teeth are bursting out, because they have an obtuse point and are pretty thick. The incisores, however, resemble a sharp wedge; hence they more easily cut through the incumbent membrane than the former. But the molares, although they have a broader surface than the canini, and also have four points, are more easily borne by the child, because these points do not appear at one and the same time but successively."* Fauchard, although he has adopted the same opinion as Van Swieten respecting the incisores, nevertheless, comes nearer the truth when speaking of the molares; he says, "The incisores, being small and sharp, cut through the gums with less difficulty than the canini, and the child suffers much less by them. The molares, however, which are considerably larger and nearly square, pierce the gums with much greater violence than any of the others, but as they appear very slowly and the child gains strength and age, it can support with less danger the pain produced by them."† Dr. Underwood differs from all these authors, for he says, "It will be frequently necessary to lance the gums several times, on account of the extraordinary difficulty with which some infants cut their teeth, especially the double

* "Cum autem omnia hæc mala a tensione, puncturâ, laceratione, gingivarum nervosarum, sanguinolentarumque, oriantur, patet facile, omnia hæc mala magis metuenda esse, dum erumpunt dentes canini, qui obtusum apicem habent, et satis crassi sunt. Incisores acutum referent cuneum; hinc facilius membranam incumbentem findunt. Molares autem, licet latiore superficiem, habeant quam canini, et quatuor apices, facilius seruntur; quoniam non simul et semel, sed successive, illi apices emergunt." *Comment.* vol. xiv, p. 746.

† "Les dents incisives étant plus petites et plus tranchantes, percent plus aisément que les canines, et font beaucoup moins souffrir l'enfant. Les molaires, qui sont bien plus grosses et presque carrées, percent les gencives avec plus de violence; mais comme elles sont plus tardives, et que l'enfant a plus d'âge de force, il supporte plus aisément la douleur." *Le Chirurgien Dentiste*, vol. i, p. 50.

ones, which are furnished with two or more knobs or points. Fever, purging, and even convulsions, will sometimes arise from only one point of a large tooth offending the periosteum that covers it; and, being nearer the surface than the other points, the lancet sometimes does not completely divide the membrane that lies over the rest; and this part not being injured by the tooth, the symptoms subside on having divided that portion of membrane that was inflamed. But, in a little time, another point of the same tooth is found to irritate the periosteum, and calls for the like assistance of the lancet, which again removes all the complaints.”* Thus we find all the temporary teeth accused, by one author or another, of producing, as they say, by their efforts to burst out, almost every symptom and complaint that has been mentioned by nosologists; and each author, in support of his own doctrine, attributing greater danger to the appearance of certain teeth than others, as well as the period of their appearance.

It cannot be doubted but that complaints which arise from very different sources, have been and are at present attributed to teething.† The celebrated Sydenham tells us, “It is a common observation that infants are frequently thrown into fevers by the pains attending dentition, which are not easily distinguished from fevers of another kind. I have been long tormented with the treatment of those, nor until lately, could I be persuaded that any of them that were entrusted to my care, were restored to health so much by art as accident, until having been frequently reminded of a remedy, not very celebrated, but rather disregarded for being in common use, I, however, ordered it and found it answer my utmost expectation, being preferable to any medicine I had previously tried. It is two, three, or

* Diseases of Children, vol. i, p. 217.

† We may safely assert, that dentition is not a disease in itself, any more than parturition is, and that when dentition progresses in conformity with natural laws, that it should not be attended with any disturbance of the general economy of health, but when the system is enervated, and dentition abnormal, it becomes one of the most destructive agents to the health and life of the infant that the physician has to contend with.—Ed.

four drops of spirits of hartshorn according to the age of the child, given in a spoonful of black cherry water or any other proper julap every fourth hour to the fourth or sixth time.”* I think it very probable, Sydenham fell into the very snare he wished us to avoid, for it is not likely that a fever occasioned by dentition, would yield so frequently, as he says, to a few drops of spirits of hartshorn, at least if such violent irritation is produced in the system as is so generally supposed: it appears, however, that this medicine has been in considerable use and repute, for Boerhaave tells us, that convulsions arising from dentition have been happily cured by a small dose of the volatile alkali.† Such convulsions I should think arose from some derangement either of the stomach or bowels and not from teething.

It is not my intention to point out the medical treatment of children during these periods, but concisely to mention in what manner as far as I can judge the appearance of the teeth might occasion violent and dangerous symptoms, and also how they may be avoided. It is likewise necessary to investigate the present mode of lancing the gums, an operation which has been in general use and recommended by the first authorities.

I designedly omitted, when treating of the commencement and formation of the permanent teeth, saying any thing particular respecting the change which then takes place in the sockets of the temporary; but reserved it for this place. Soon after the permanent sacs have commenced, and that each sac

* “Vulgo enim notissimum est infantes à doloribus ex dentitione ortis, sæpius in febres agi, quæ haud ite facilitè ab alterius generis febribus internoscuntur. In harum ergo curatione diu multùmque angebar, nec nisi nuperis his annis certò mihi persuadere potui quemlibet ex illis qui meæ curæ concrediti ad sanitatem restituti fuerent, tam arte quàm casu convalescisse, donec tandem de felici successu remedii haud ita celebris, imo ad tritum ejus usum planè contempti, frequenter admonitus, illud ipse quoque præscriberem; quod etiamnum præ cæteris quæ mihi innotescunt medicamentis optimè votis hic respondet. Ejusmodi verum est guttæ duæ, tres, vel quatuor spiritus cor. cerv. pro ratione ætatis, in cochleari uno vel altero aq. cerasor. nigr. vel julapii alterius appropriati exhibeantur quarta quaque horâ ad vices quatuor vel sex.” *Opera Universa*, p. 504.

† Aphor. 1378.

becomes surrounded with a bony socket, there is a disposition in the plates of the alveolar processes to contract a little over the surfaces of the temporary teeth, and as Mr. Hunter justly remarks, "The alveolar processes grow, and for some time keep the start of the teeth, and perhaps the reason why the mouths of the sockets have this tendency to contract, is in order to support the gums, and prevent them being injured before the teeth come through."* The structure of the gum I likewise reserved: it seems a substance *sui generis*, externally it is covered by the cuticle which lines the mouth, and which can be readily separated from it, immediately under the cuticle it appears composed of cellular membrane and a plexus or net work of vessels. The external periosteum of the jaw seems lost in it, and I could not afterwards by any means separate it into lamellæ. The gum seems a substance, as I have had frequent occasion to mention, designed in a certain degree to form and afterwards to accompany and support the teeth through life, and in old age to become a callous covering to the jaws, deprived of teeth and alveolar processes. The gums in general are not possessed of much sensibility, but when irritated even by slight causes, they are apt to inflame and become remarkably tender and painful, similar to the *tendinous aponeurosis*, &c.

In all the examples we have been examining, I have shown that in proportion as the teeth rise, the upper parts of the sockets exposed to their pressure are absorbed; and I have repeatedly shown that as soon as the investing membrane had perfected the cortex striatus, it was wasted, the gum we have seen partakes of this tendency to waste or is absorbed and the teeth commonly pass with great ease through it and frequently without the knowledge of the mother or nurse. In some few cases, however, where nature does not preserve her regular mode of action, violent symptoms may arise: for instance, if the root or roots advance more rapidly than the body of the tooth, the vessels of the gum and even those of the investing membrane may become inflamed. Such cases, however, I look on to be

* Nat. Hist. p. 75.

very rare, and I do not think, that this natural process in the animal economy, in which all animals (man excepted) seem to suffer little or no inconvenience, should be accounted and ranked as a most fatal disease. Dr. Caddogan, in his essay on nursing, introduces the following valuable remarks, "Breeding teeth has been thought to be and is fatal to many children; but I am confident this is not from nature; for it is no disease, or we could not be well in health till one or two and twenty, or later. Teeth are breeding the greatest part of that time; and, it is my opinion, the last teeth give more pain than the first, as the bones and gums they are to pierce are grown more firm and hard."

We shall now examine into the means of relief, which have been employed, and those also which may occasion the teeth to cut easily. Boerhaave says,* "this may be effected, 1st, by softening, cooling, and assuaging the gums, with soft, glutinous and antiphlogistic remedies. 2dly, by often rubbing them with hard smooth bodies. 3dly, by cutting them with a lancet." The practice of rubbing the gums of children with coral and other hard but smooth bodies, in order to make the teeth cut easily, is still recommended by all writers on the diseases of children. Dr. Underwood observes, "severe symptoms could not arise merely from the teeth piercing the gum, which it has been said is not a very sensible part."† He, therefore, recommends the use of coral, &c. but chiefly depends on the operation presently to be mentioned; coral or any other smooth hard body which is usually given children to bite, with a view to assist the cutting of the teeth, I look upon to be a most dangerous weapon put into their hands to destroy themselves; for as the teeth rise and become slightly elevated above the edge of the socket, those hard bodies press and bruise the gum between them and the sharp points or edge of the tooth underneath: inflammation and its consequences undoubtedly follow, and in

* "Quod fit. 1, gingivas emolliendo, refrigerando, leniendo, mollibus, glutinosis, antiphlogisticis; 2, sæpe atterendo ad corpora dura, glabra; 3, dissecando ope lanceolæ." *Aphor.* 1377.

† Diseases of Children, p. 214.

this way I am firmly persuaded the lives of thousands of children have been lost. Dr. Munro warns us against the use of such substances, and recommends the child to be allowed to make use of its own fingers, he does away the old prejudice, that if children were allowed to suck their fingers, the size of them would be diminished. I would add to this, that the nurse may now and then rub the gums of the child gently with her finger, where a tooth is about to appear; children seem to receive great pleasure from it. Every species of gum-stick should be undoubtedly laid aside, a child should not be allowed even a crust of bread, unless the hard outside part was scraped off and afterwards moistened in milk or water.

From these observations, it is sufficiently obvious that violent symptoms may arise from the irritation occasioned by the appearance of any one of the temporary teeth or even the permanent. Dr. Rutherford saw a case of chorea produced in a child about eight or nine years of age, by the permanent incisors cutting at the internal part of the mouth, and Dr. Munro relates a case of its being produced in a youth by the appearance of the wisdom teeth.

With respect to lancing the gums of children, Dr. Underwood says,* “when it is found necessary to lance the gums, (which is ever, at least, a safe operation) it should always be done effectually with a proper gum lancet, which will sufficiently divide the gum or strong membrane that covers the teeth. The lancet should always be carried quite down to them, and, in certain cases it will often be proper to draw the lancet along a great part of one or even both jaws, at the same operation. Some writers, however, and Dr. Miller particularly, have advised not to cut quite down to the teeth, but only to scarify the gums, unless the teeth are very near, for fear of injuring the succeeding teeth. But this is a needless scruple, and I apprehend arises for want of duly attending to the state of the teeth. For the first teeth of infants constantly become carious at the roots, and are loosened and expelled by that means, when

* Diseases of Children, vol. i, pp. 213, 218, 220.

left to nature alone; and though the upper parts of the new teeth are in contact with the carious bottoms of the first set, they never suffer from this circumstance. I have, however, written from *experience*, and am *perfectly satisfied* of the propriety and safety of what I have ventured to recommend." Dr. Underwood, however, does not seem to have paid much attention to the state of the teeth in children, nor, indeed, to the animal economy; if he had, he would not have asserted that the roots of the temporary teeth become carious in order that they might be expelled. Lancing the gums, likewise, is not altogether so simple or safe an operation as Dr. Underwood seems to think, for from what I demonstrated in chapter iv, respecting the connection which subsists between the temporary and permanent teeth, the connecting membranes and sacs of the permanent teeth must have been constantly cut by the common mode of operating; the formation of the permanent teeth must, of course, be much impeded, and, probably, sometimes entirely destroyed, by the frequent repetition of the operation. Lancing the gums of sickly children has, sometimes, terminated in gangrene and death; my late friend, surgeon Dease, told me he met several instances of this kind. On the whole, the operation has been often performed unnecessarily and without benefit; complaints, as I said before, arising from totally different sources have been attributed to teething, and recourse immediately had to the lancet. Dr. Hudson says, "concerning your question about lancing the gums of children, I have avoided making it a source of revenue to myself, convinced from experience of its futility, except in inflammatory cases, and where the teeth were near the surface; in such cases, the lancet gave relief, and I believe seldom or never on other occasions. Where I have operated by advice of the attending physician, it is true, many children have recovered after the operation, but I could never fairly say the recovery was in consequence thereof."

When we are convinced of the necessity of performing the operation, the incision should be made towards the external plate of the alveolar processes, so as to avoid the connecting membranes and sacs of the permanent teeth, particularly those

of the incisores and cuspidati, those of the bicuspidés are more easily avoided on account of the flat and broad surfaces of the temporary grinders: or two oblique incisions might be made with a similar view, beginning at the internal part and meeting in an angle about the middle of the tooth or external plate of the alveolar process, so that the connecting membranes and permanent sockets might be contained within the space formed by both incisions, the method of doing which can be easily conceived by observing the relative situation of the temporary and permanent sockets. Also, where advisable a small horizontal portion of the gum might be cut out, particularly over the incisores, &c.

The advantages gained by the operation I conceive, are, in a great measure, owing to the tension of the vessels, &c. being removed by the small quantity of blood drawn from the inflamed part of the gum.* I have been particular in pointing out the order and period in which the temporary teeth appear, that we might not err in lancing the gum over the proper tooth, that is, the one which is about to appear.† We should by no means cut or hack the gums in the manner Dr. Underwood recommends, nor do I see any necessity of penetrating so deep, or drawing the lancet over a great part of one or both jaws at the same operation, as he also says is sometimes necessary. Dr. Underwood was certainly not aware of the mischief that might be done to the sockets and neighboring imperfectly formed permanent teeth when he recommends such an extensive incision. Neither can I see the necessity there is of performing the operation nine or ten times over one tooth as Dr. Underwood and Mr. Hunter have done, for, if the gum is frequently lanced previous to the tooth rising above the edge of the socket, its formation is impeded, the root or roots of course do not increase rapidly, and they for the most part appear later than they otherwise would do.

* That this local depletion often relieves the sufferer, can hardly be questioned.—*Ed.*

† Vide chap. iii.

By a frequent repetition of the operation, I have sometimes seen the temporary incisores appear through the gum imperfectly formed, and soon after their appearance they became loose and fell out, no roots being formed to retain them in the sockets. I shall conclude by saying, that I do not think lancing the gums of children is altogether so safe an operation as has been heretofore imagined, and that great caution should be used in the method of performing it, and also we should be perfectly certain of its necessity. For as I often said before, complaints arising from totally different sources have been attributed to teething, and the children tortured without receiving the slightest benefit or relief by the operation.

It is necessary to add, that the appearance of the wisdom teeth sometimes occasions a vast deal of uneasiness and pain, particularly when they are formed immediately under the zygomatic process of the lower jaw or tubercle of the upper; this happens where the jaws do not extend sufficiently so as to allow a regular disposition of the teeth, the gum being squeezed and bruised by the frequent motion of the jaw in chewing, becomes inflamed, amazingly tender and painful. Lancing or cutting out part of the gum over the tooth sometimes gives relief. But Mr. Hunter and other modern surgical writers being expert at operating, recommend (in those cases where lancing the gum does not give relief) to have the wisdom tooth taken out; expert, indeed, they must be who could take out a tooth in such a situation, nor could it be effected without tearing away a considerable portion of the coronoid process or jaw. What I have found answer every intention in such cases, is to take out the middle grinder, the wisdom tooth soon after moves forward into the place of the former; and the violent symptoms of course cease.*

* By extracting, not the advancing wisdom tooth, but the tooth opposite, which meets the irritated soft parts covering the advancing tooth, will, in a great measure, relieve the difficulty under which the patient labors.—*Ed.*

SUPPLEMENT.

SOME time previous to the publication of my inaugural dissertation in September, 1798, whilst assisting Dr. Munro, Jr., to arrange some of his father's valuable preparations of the teeth, I observed amongst them an elephant's grinder, and at once discovered its beautiful structure, and likewise the manner of its formation. In order to ascertain these facts, I got permission from the doctor, after my own plan, to have a longitudinal section made of it and afterwards polished, one-half of which he kindly presented me with. I immediately showed and explained its structure, &c. to my learned friend Dr. Rutherford, and also to Dr. Munro, Sr., as well as many other gentlemen. A drawing was copied from it by Mr. Alston, which I entrusted to an ingenious artist, Mr. Scott, to engrave for me, the plate of which I intended to have annexed to my thesis, but found it could not be finished in time for the graduation.

At this period John Corse, Esq., came down from London to Edinburgh, and as he had made many interesting and valuable observations in the East Indies on the economy and natural history of the elephant, and also on their mode of dentition, Dr. Munro, Sr., mentioned to him the discoveries I had made on the structure and formation of the teeth in general and particularly on the grinders of the elephant, and shortly afterwards was kind enough to introduce me to him. Mr. Corse told me he was not at all acquainted with the structure of the elephant's teeth, nor, indeed, with the structure of the teeth of any gramivorous animal, that his object alone was to point out what he had discovered, scil. "The mode of dentition of the elephant, or the progressive motion of one grinder into the place of

another in proportion as the anterior one is worn away." According to appointment we met at my apartments in order that I might demonstrate my preparations of the teeth in general to Mr. Corse: which I did, and also explained to him how a section should be made of an elephant's grinder to show its internal structure, a section similar Mr. Corse confessed he never before saw. Dr. Munro, Jr., and my friend Dr. William Armstrong were present at this demonstration. Mr. Corse told me he would undoubtedly do me justice, and that he would mention my discoveries of the structure and formation of the elephant's grinders in his intended publication on the different species of Asiatic elephants and their mode of dentition.

Mr. Corse requested me to meet him in London, and that he would give me permission to prepare, in any manner I pleased, several valuable preparations of the heads of elephants he had collected and brought from the east, and to publish drawings from them according to my own plan; unfortunately, I could not at that time take advantage of his kind offer.

Mr. Thomas Blizard, of the London Hospital, was in Edinburgh nearly at the same time, to whom also I demonstrated my preparations.

Having returned to Dublin in November, 1798, I determined as soon as possible to visit London and avail myself of Mr. Corse's generous offer, but could not arrange my affairs so as to go there until September, 1799. On my arrival in London I immediately waited on Mr. Corse and found to my very great astonishment as well as disappointment, that he had already published a section similar to mine of an elephant's grinder, without once mentioning my name as having originally discovered its structure and formation, and also some other of my observations which shall afterwards be noticed.*

Mr. Corse endeavored to apologise to me for this conduct, by saying, that he had explained my observations to Mr. Everard Home of London, and, also, that he had put my thesis (a copy of which I presented Mr. Corse) into his hands, Mr. Corse

* Mr. Corse's Observations on the different species of Asiatic Elephants. Tab. xii. *Philosophical Transactions*, for 1799.

therefore *supposed* Mr. Home would have mentioned my discoveries in his intended work which was to have been added as a supplement to Mr. Corse's. However, on looking over Mr. Home's work,* I was not a little surprised to find that he (Mr. Home) had published most of my discoveries as his own, respecting the teeth of graminivorous animals, and artfully contrived to alter some of the terms I made use of; for instance, what I have uniformly called bone, Mr. Home calls ivory, and what I have called the crusta petrosa, Mr. Home calls bone. He has, of course, avoided mentioning my name or referring to my thesis.

Having brought to London with me a few impressions of the plate representing my section of the elephant's grinder, I presented them, and at the same time explained this illiberal transaction and my priority of claim to the discovery of the structure and formation of the teeth of graminivorous animals in general, to several of the first medical characters I had the honor of being introduced to, and also to that liberal patron of science the President of the Royal Society, Sir Joseph Banks. This, in some measure reconciles me to the unforeseen delay of its appearing previous to this period. I have also to add the pleasing reflection of my priority of claim being established and supported by the University of Edinburgh.

It now remains for me to expatiate a little on both these works, (scil. Mr. Corse's and Mr. Home's,) and to explain the structure and formation of the elephant's grinders, which (notwithstanding the advantages Mr. Corse and Mr. Home have had in the possession of my thesis and observations) neither of them as yet perfectly understand; and although I have had an opportunity of seeing all Mr. Corse's and Mr. Hunter's valuable preparations I do not find it necessary to deviate in the slightest degree from the manner in which I originally explained their structure and formation to Mr. Corse.

As many very valuable and interesting observations have

* Mr. Home's Observations on the Structure of the Teeth of Graminivorous Quadrupeds. *Philosophical Transactions*, for 1799.

been made by several authors on the different species of elephants, their mode of dentition, as well as the structure and formation of their grinders, most of which were published in the Philosophical Transactions about the beginning of the last century, I shall occasionally refer to them.

I mentioned to Mr. Corse in Edinburgh, that the pulp of an elephant's grinder was divided into a number of conical processes, and that duplicatures of the investing membrane passed down between these processes to form the cortex striatus; that ossification commenced on the highest point or points of these processes, and formed conical bony shells on them, which extended downwards for many inches previous to the junction of their sides; that as soon as the bony shells were perceptible, the internal lamella of the investing membrane began to deposit the soft earthy matter of the cortex striatus on their external and upper surface, and that as soon as it was crystallized on the upper part of the shells, the investing membrane assumed a different mode of action and began to deposit a crusta petrosa on their points and sides, in order to fill up the interstices or spaces between the shells where the membrane passed down to form the cortex striatus, in a similar manner to those of the horse; that previous to the appearance of the tooth through the gum, one continued line of the cortex striatus could be traced as far as the ossification and junction of the sides of the shells were complete, but that in proportion as the tooth came into use and was worn down by grinding, the connection of the cortex striatus, as well as that of the crusta petrosa, were cut off, that then the crusta petrosa and bony part appeared alternately between the ridges or plates of the cortex striatus on its grinding surface; that as ossification advanced, the pulp extended and sent off processes to form roots, that the tooth rose and continued to rise by the formation and addition of new bony matter to the roots, in proportion to the detrition of the grinding surface, until the entire tooth was worn away; that the crusta petrosa was deposited on the external surface of the tooth as long as any portion of it remained within the jaw; that the junction of the sides of the shells and plates of the cortex stria-

tus was in every respect similar to what I had observed in the teeth of other graminivorous animals.

I then showed and explained to Mr. Corse my section and drawing of the elephant's grinder which was perfectly formed and a considerable portion of it worn away by grinding. One continued winding line of the cortex striatus can be traced. The bony part on which the fibres of the cortex striatus are arranged appears wavy. The plates of the cortex striatus had been originally nearly as long on the side of the tooth which was most abraded, as those at the opposite side, and the vessels entered the hole at one side of the apex of the fang, to nourish the remains of the pulp contained in the cavity of the tooth. I shall now request the candid reader to compare this description with that of tab. xii, of Mr. Corse's work, and also with tables xiii, xv and xvii, of Mr. Home's. Also, to compare the comparative dental anatomy of my thesis, and also that which refers to the manner by which animals shed their teeth, with that of Mr. Corse's, tab. viii, figs. 1 and 2, from which figure the idea of both these were taken, to show the junction of the bony shells, and how the pulp becomes separated from the investing membrane.

I mentioned in my thesis, that the crusta petrosa was much harder and more brittle than the proper bony part of a tooth, but less hard and brittle than the cortex striatus, and that of course it did not wear down so fast as the bony part. In this, probably I have been too nice, for in one case the crusta petrosa wears faster than the bone, in another the bone wears faster than it, and although in the cow, sheep, &c. it is more brittle than the bony part, in other animals it may not be, nor is it so hard on the tusks of the spermaceti whale, sea cow, nor even on the grinders of the elephant.

In one of the interviews I had with Mr. Corse in London, and at which Dr. William Armstrong was present, he said the reason why he did not mention the substance I called the crusta petrosa in his work, was, that in about a month after he had seen me in Edinburgh, he had several conversations with Mr. Home in London on this subject, and that on showing Mr. Home my

thesis and his valuable preparations, (the physiology of which Mr. Home at that time was not well acquainted with,) Mr. Home said the substance I called the *crusta petrosa* was not materially different from common bone, and that it would be found softer than the centres of the strata composing the grinder; and because, on polishing a section of one of the elephant's grinders, this substance was found softer than the bone, Mr. Corse said he gave up the idea of a third substance entering their composition. This is a flimsy excuse indeed, for as I mentioned in my thesis, the *crusta petrosa* differs in color as well as texture and formation from the other two component parts of the tooth, scil. the *cortex striatus* and bone. Mr. Corse, however, in his work has altered the appellations I made use of and slyly marks the three different component parts of the tooth; for instance, in explanation of plate xii, he calls the *crusta petrosa* the *bony crust*, and the proper bony part of the tooth he calls the *bony matter*. Explanation of plate xii, *f. f. f. g. g. h. h. h.*

After this simple statement of facts, Mr. Home has the modesty to assert, "from these two sources, viz. Mr. Corse's observations and preparations, and also preparations of the elephant's teeth preserved in spirit in Mr. Hunter's collection, I was enabled to procure every information that was required, to explain the structure of the elephant's teeth, and to point out the general principle upon which all teeth are formed that have the enamel intermixed with the substance of the tooth; *a subject, as far as I am acquainted, not hitherto investigated.*" Mr. Home adds, "I was desirous that the facts which I *had discovered* respecting the *structure* of the elephant's teeth, should be introduced into his paper, to render the account more complete: this offer, Mr. Corse, however, declined, not choosing to bring forward any thing that was not wholly his own."* Did Mr. Home suppose that my discoveries and observations on the teeth of man and various animals (because they were published

* Mr. Home's Observations, &c. *Philosophical Transactions*, for 1799, pp. 1 and 2.

in a *thesis*) would be thrown aside and not noticed? Did Mr. Corse and Mr. Home suppose I would not, or could not vindicate my own priority of claim and make this transaction public? I do it in support of science, more than for my own celebrity; I do it to put a stop, if possible, to such plagiarism, and give a zest to those who are engaged in the studies of nature.

To enter into a full refutation of many of the principles laid down by Mr. Corse and Mr. Home would be foreign to my present purpose; I cannot, however, pass over some of their remarks and erroneous ideas. Mr. Corse says, page 9, "a grinder is composed of several distinct laminæ or teeth, each covered by its proper enamel; and that these teeth are merely joined to each other by an intermediate substance acting like a cement." This was the opinion of the celebrated Ray.* It was also the opinion of Dr. Patrick Blair, who has displayed great anatomical knowledge, perseverance and accuracy, in his dissection of an elephant that died at Dundee in Scotland, in 1706. He very nearly discovered the structure and formation of their teeth, but calls the bony shells the rudiments of the teeth.† "Several of which rudiments he observed lying stratum super stratum or placed perpendicularly across the jaw, they were two or three times intersected by membranes whereby they could be disjoined, but after he had taken out several of these rudiments, he observed no more such separation. Where the ligaments cease they become extremely solid and ponderous, and at their upper extremity half round and sometimes formed into digitations, from which there run several ridges and sulci. It is observable, that at their upper extremity there is a lamina, which being convex toward the jaw, and concave toward these rudiments of teeth, does as it were knit their solid extremities together, before they appear without the jaw. It was likewise the opinion of Dr. T. Molyneux,‡ Tentzelius,§ and others.

* "Plurimi dentes in os solidum et durum ita infixi sunt, ut cum eo et inter se unum et continuum corpus efficiant." *Synopsis Animal. Quadruped.*

† Philosophical Transactions, abridged by Henry Jones, vol. v, part i, page 120. ‡ Ibid. vol. iv, part ii, p. 238. § Ibid. vol. ii, p. 440.

If an elephant's grinder was composed of several distinct teeth, and if each of them were covered by its proper enamel, there should have been different pulps and membranes to form each tooth: but it is not so, there is, as I told Mr. Corse, but one pulp which is divided into a number of conical processes, and in proportion as the anterior processes are ossified, the pulp sends backwards a certain number of additional processes, to enlarge the tooth. If, likewise, a grinder, or case of teeth, as Mr. Corse calls it, was formed of a number of teeth merely cemented together by an intermediate substance, there could not be that beautiful winding and continued line of the cortex striatus over the bony part which I discovered, as far as the junction of the sides of the shells is complete, and which connected line as well as the arrangement of the fibres of the cortex striatus Mr. Corse and Mr. Home have represented after my plan, although the fibres of the cortex striatus, owing to the peculiar arrangement of them, are not so distinct in a section or fracture of an elephant's tooth, as in those of the cow, &c.

I have shown that Dr. Blair, in a certain degree, noticed the substance I have called the *crusta petrosa* in the elephant's grinders, but in addition to his ingenious remarks I will add those of the Rev. Mr. Morton, which are introduced in Sir Hans Sloane's essay on the teeth and bones of elephants.* Mr. Morton says, "the grinder whole, or, however, all the pieces of it I could find, (for it was broken into three or four in taking it up,) being put together as they grew, exhibit thirteen or fourteen parallel lamellæ; each of which extends the whole length and almost the whole thickness of the tooth; and of these for the main it is composed. But in a live or perfect tooth these lamellæ do not appear so plainly, being in part crusted over with a white osseous crust or integument, which in this fossil tooth is almost wholly perished and gone, insomuch that the lamellæ are more exposed to view. From the root to the top in the longest part, which is near the middle of it, it is just seven inches long. None of the lamellæ are contiguous; there interposes betwixt them a thinner plate of a white color and a

* Philosophical Transactions, abridged, vol. vi, part iii, p. 30.

laxer texture. Three or four of the outmost at one end of the pile appear undulated at the top of the tooth, are near as broad at top as at the root, and have a blunt ending. The rest of them are by degrees contracted to a point, are gradually shorter and shorter to the other extremity of the pile and also bend a little over one another. And each of them, as it approaches the top divides, as it were, into several smaller teeth." This description of Mr. Morton's is very accurate and concise; if he had made a section similar to mine, he would have noticed the three component parts of which an elephant's tooth consists; the substance I have called *crusta petrosa* he calls the *osseous crust*, but did not understand the manner of its formation; in this respect Dr. Blair was better acquainted with the subject.

I have mentioned, that the investing membrane, after it had deposited and perfected the cortex striatus on the teeth of gramivorous and ruminant animals, assumed a different mode of action, and deposited the *crusta petrosa*; that the upper grinders in general of the horse remained sufficiently long under the gum to allow the internal cavities to be filled with the *crusta petrosa*, otherwise they would be filled with broken particles of the teeth and food, as they are in the cow, sheep, deer, &c. the nourishment being cut off from the internal duplicatures of the membrane by the appearance of the tooth. But as an elephant's grinder is differently constructed, the processes of its pulp and shells being placed almost perpendicularly across the jaw, and the interstices between them extend from one side of the socket to the other, the internal duplicatures of the investing membrane continue to be nourished from the sides, even after the upper part of the tooth has been perfected, and that part of its membrane wasted by the appearance of the tooth through the gum. This beautiful contrivance was necessary, otherwise, as the processes of the pulp elongate, and the bony shells extend downwards on them many inches previous to the junction of their edges, the upper part of the cavity or interstice between them would be filled by the *crusta petrosa*, whilst the lower part of it would be empty, which, sometimes, though seldom, happens in the upper grinders of the horse. The tooth would not

be so strong or lasting as it is, nor would the earthy matter of the cortex striatus be perfectly crystallized down to the junction of the shells, but remain in a soft state.

As the lower and alternate edges of the shells must be joined, previous to the deposition and crystallization of the cortex striatus on that part of the tooth. In this growing tooth (with which Mr. Corse was liberal enough to present me) several of the posterior shells were as yet quite separate, sections of two only of them are represented, which will give an adequate idea of the others, excepting that they are progressively smaller; the number of these shells varies according to the kind of tooth or age of the animal, being from four to twenty-three.* In fossil teeth I have, however, counted thirty-four of them. In proportion as ossification advances and the cortex striatus is perfected, the crusta petrosa is deposited, fills up the interstices between the shells, and unites them in a certain degree at the upper part a long time previous to the junction of the edges of the shells at bottom, this must necessarily happen on account of the gradual progress of the formation of the tooth. If the shells, as Mr. Corse says, were different teeth, and merely cemented together by the crusta petrosa, it would pass down quite through the entire substance of the tooth; but it does not, it terminates at the junction of the bony shells and plates of the cortex striatus. The crusta petrosa serves a purpose similar to that noticed in chapter viii, with respect to the teeth of the horse, &c. it extends considerably beyond the shells and renders the interstices between them smooth, as Mr. Morton well observes. In proportion as the alternate edges of the shells unite, they complete the body of the tooth from which the roots commence.

In proportion as the rudiment of the first grinder is tolerably advanced, its membrane sends backwards a process to form a second, and from the second to the third, and so on, both of which are at first contained in the same socket, but as ossification advances they become separate: a hole of communication

* See Mr. Corse's Observations, p. 11.

however is preserved, through which the connecting membrane passes. This connection Mr. Corse speaks of (page 14) and borrowed the idea from my observations, but did not mention it as my discovery, because Mr. Home told him "he did not think it worthy of notice."

Dr. Moulins, Dr. Blair, Dr. T. Molyneux, and many others, were very much at a loss to determine the number of grinders an elephant in general ought to have, on account of the irregular situation of the teeth in different elephants, and also the use of those they observed in an incipient state; Dr. Moulins says in his anatomical account of the elephant accidentally burned in Dublin in the year 1681, (London, 1682) page 40. "There were besides the tusks only four teeth in each jaw, two in every side, he had no incisores. The length of each of the inner teeth of the lower jaw was about six inches and a half, but the outward of the same jaw was only one inch and three-quarters long. The length of the hinder tooth in the right upper jaw was four inches, but that of the opposite was but three, the two outward teeth of the upper jaw were somewhat longer than those of the under, the greatest breadth of the teeth was two inches and three-quarters, the height of the teeth above the jaw was about one inch and three-quarters." Dr. T. Molyneux ingeniously observes,* "it appears that the number of molares in the elephant is not certain; and although by the observations of Mr. Du Verney, Dr. Moulins, and Dr. Blair, who dissected three different elephants, it appears that each of them had eight molares, yet in the division of them nature observes no rule; for Dr. Moulins found that in the upper jaw the inner tooth on one side was bigger than its fellow, and Mr. Du Verney and Dr. Blair had on both side the much greater tooth outwards: whereas the Westminster skull, on the contrary, has only a small one outwards, and the much greater grinder within. In this skull there were only six teeth, viz. one in each lower jaw, and two in each of the upper: the upper small teeth are much worn by grinding, and both together are about an inch

* Philosophical Transactions, abridged, vol. iv, part ii, p. 244.

longer than those of the under jaw ; the upper teeth have a convexity which answers to the concavity of the under teeth, a circumstance not observed by any one else." It is singular that Dr. Molyneux did not benefit by the remarks of Dr. Blair on this subject, most of which are very interesting. Dr. Blair says, (page 116, 117 and 121,) "in the upper jaw there are two teeth at each side, the back one of which does not grind, but serves, as it were a wedge, to keep the anterior firm in its place. Dr. Moulins takes no notice whether the hinder teeth of the upper jaw grind or not; but here as I have said, not only both the hinder teeth are free from grinding, but also part of the fore teeth (tooth he means) of the left side. The situation of these teeth, for what I know, is peculiar to this animal. The teeth of the lower jaw exceed those of the upper about two inches in length, by which it appears that the motion of the lower jaw must be very great in mastication, and that the elephant for the most part moveth the jaw from behind to before; and scarcely from one side to the other, as in animals that ruminate or chew the cud." This last observation of Dr. Blair's, is perfectly just with respect to the motion of the under jaw in grinding, the sockets and condyles of their jaws are beautifully constructed for this purpose, and although the upper teeth of the elephant described by Dr. Molyneux were longer than those of the under, it very seldom happens so, if my recollection does not fail me. The motion of the under jaw of the beaver is similar to that of the elephant, and although the rabbit, hare, &c. move their jaws likewise from behind to before, they possess in addition a considerable lateral motion. Dr. Blair adds, page 121, "before we quit the lower jaw, I hope it will not be impertinent to inquire, whether or no these *rudimenta dentium* may be supposed, in process of time, to descend and expel those teeth already formed, and succeed in their place." The ingenious Dr. Blair, having had but one elephant to examine, could not follow up this idea, he reasons rather against the possibility of its taking place, and adds many arguments *pro* and *con* too numerous to insert. Mr. Corse, however, claims the entire merit of this discovery ; I think he ought to have noticed Dr. Blair's

observations, and should not say, "the ingenious Dr. Blair, far from suspecting a regular succession of the grinders, attempts to prove such succession to be impossible. He is equally erroneous in many other respects," (page 10.) Mr. Corse, however, has (by the very great advantages he possessed, and the great industry exemplified in collecting so many heads of elephants of different ages) thrown great light on this idea of Dr. Blair's, and cleared up the difficulties the older writers labored under, respecting the number and situation of the teeth in different elephants, and observes, (page 13,) "an elephant may at one period have only a single grinder in each side of either jaw, (Mr. Corse I suppose means in use,) at another period, there may be one and part of a succeeding grinder; even a still greater variety in the appearance of the grinders will take place according as the anterior one is more or less worn away and the waste supplied by its successor." These facts are beautifully exemplified in plates annexed to Mr. Corse's work.

Mr. Tenon has published an account of his observations on the structure and formation of the teeth of graminivorous animals, particularly the horse, in the *Mémoires de l'Institut National des Sciences et Arts*, Paris, Thermidor an. VI, answering to the year 1798 of our style, some short time previous to my thesis being printed. He notices the substance I have called the *crusta petrosa* and calls it the *cortical osseux* or simply *cortical*,* the other two component parts he calls bone and enamel. He has taken considerable pains to ascertain and point out the age of a horse by the wearing down of his front teeth, the structure of which he seems better acquainted with than that of the grinders; he gives drawings and sections of the first but no sections of the latter, and does not observe the difference between the upper and lower grinders; his work, however, contains many ingenious observations, and although he did not enter with sufficient minuteness into either the structure or manner of formation of their teeth, yet his work merits particular attention. With respect to the manner of formation of

* Tom. premier. *Sciences Mathématiques et Physiques*, p. 568.

the crusta petrosa, he supposes the investing membrane becomes ossified; he was aware, however, that the enamel was first formed, and says, (page 611,) "*Que la formation de l'émail précède l'ossification de la membrane qui produit le cortical,*" I have asserted that the crusta petrosa is merely a deposition by the membrane; if the investing membrane was ossified, the body of the tooth would not have an external periosteum: the use of the crusta petrosa and membrane I have frequently noticed. Mr. Tenon likewise observes, that the crusta petrosa is softer than the bony part, and mentions it is to be noticed on the grinders of the elephant, &c.

This essay of Mr. Tenon's was in the library of a friend of mine in London some months previous to my visiting that place in September, 1799, whether Mr. Home saw it or not, I cannot pretend to say, he has, however, hit on the idea of Mr. Tenon with respect to the formation of the crusta petrosa, for he says, (page 7,) "the intermediate substance which may be called bone, was formed upon a species of ligament situated immediately underneath the gum." This substance (the crusta petrosa) differs materially from bone, for it is neither fibrous nor lamellated, nor are thin sections of it near as transparent as those of bone, and although Mr. Home says, (page 5,) "it proves to be similar, in its texture and formation to common bone," yet in another part of his work he contradicts himself, for he well observes, (page 21,) "in the bony part (scil. the crusta petrosa) there are no distinct fibres nor laminæ." The name I have annexed to this substance, in order to distinguish it from the other component parts, I do not think necessary to alter, if I did I would adopt that of the osseous crust given it by the ingenious Mr. Morton. Mr. Home endeavors to apologise for Mr. Hunter's not discovering the structure and formation of the teeth of graminivorous animals by saying, (pp. 7 and 8,) "to show the figured appearance on the grinding surface of horse's teeth, Mr. Hunter rendered them black by means of fire, which did not affect the enamel, so that the white lines of the enamel were beautifully distinct on the black ground: but the bony part and the substance of the tooth were equally colored,

and had an uniform appearance. The examination of these preparations led him to believe, that the horse's tooth consisted of only two substances, the tooth itself and the enamel." Mr. Home's theory with respect to the formation of the cortex striatus is rather curious, he says, (page 4,) "this pulp is enclosed by a capsule, the cavity of which, while the tooth is growing, is filled with a viscid fluid, similar to the synovia of joints; and this fluid, by the absorption of the thinner parts, becomes inspissated to a proper state for crystallization, so as to form the enamel, which adheres to the surface of the tooth." I shall just ask Mr. Home, what deposits the mucilaginous fluid? to answer for him, the investing membrane. My ideas, and the facts I have discovered on this subject are so frequently noticed in this essay, that they need no recapitulation. If Mr. Home's ideas were just, how does it happen that in the incisores of some animals such as the beaver, &c. only one side of the tooth is covered with the cortex striatus, although the body of the tooth was surrounded by the investing membrane?

With respect to the different species of elephants, Mr. Corse and Mr. Home might have referred to the ingenious observations introduced in Dr. Blair's work, (page 110,) by Tavernier on the difference between the elephants in India and those of the island of Ceylon, and, also, Mr. Strachan's observations on the method of taking and taming wild elephants in Ceylon, and their different species.* With respect to plate xvi, of Mr. Home's observations, which he gives to mark the difference between the Asiatic and African elephant's tooth, he will meet drawings precisely similar given by Dr. F. Molyneux in the fourth volume of the Philosophical Transactions abridged, part ii, plate iii, page 252. The difference between the Asiatic and African elephant is more fully explained by Cuvier;† and Blumanbach has given drawings of a grinder of each in his objects of Natural History. The grinder of the African

* Philosophical Transactions, abridged, vol. v, part ii, p. 176.

† Mém. de L'Institut. Nat. Des Sciences, Paris, Fructidor An. VII. Mémoire sur les Espèces D'Eléphants vivantes et fossiles, par le Citoyen Cuvier. Pls. 1 and 2.

elephant contains a much greater portion of the *crusta petrosa* than the former, the appearance of the grinding surface is likewise different.

The grinders, &c. of an unknown animal, supposed extinct, have been found in a fossil state intermixed with the tusks and bones of elephants near the banks of the river Ohio in North America, accurate drawings of their full size and a description of them are given by Peter Collinson, F. R. S. in the fifty-seventh volume of the *Philosophical Transactions* for 1767, page 464. These teeth were supposed to belong to another species of elephant, but as Mr. Collinson well observes, when compared with the grinders of an elephant, they exhibit a very different appearance. They are in length, generally, about seven or eight inches, and from three and a half to four inches in breadth; they are formed nearly in a similar manner to the human grinders, their bodies being entirely covered by the *cortex striatus*, its thickness is twice greater than that on any other animal's tooth I have met with, being upwards of a quarter of an inch; the fibres of which it is composed are perfectly evident, and although it does not pass down through the substance of the tooth, the grinding surface (owing to the irregular disposition of the bony lamellæ) is very rugged. There is not the slightest appearance of a *crusta petrosa*, so that the tooth consists of but two substances. The appearance of the grinders induced the learned Dr. William Hunter to rank this creature amongst carnivorous animals, but the celebrated Camper differs from the doctor, because the *incisores* and *cuspidati* are wanting in this beast, which are the principal characteristics of carnivorous animals: Mr. Cuvier in support of Camper's opinion refers to the rhinoceros, whose teeth in a certain degree resemble those we have been speaking of, so that they suppose it lived on the branches of trees, &c. I think, however, it is most probable the creature lived alternately on animals and vegetables, and of course was omnivorous.

With respect to the formation of the tusks of the elephant, Dr. Blair well observes, (page 111,) "as to their structure, I doubt not but they have been composed at first of a mucilagin-

ous substance, as teeth are ; and that afterwards they augment by the apposition of several laminae or strata according as the animal increases in years." That they are composed of lamellae placed one within the other, Sir Hans Sloane has clearly demonstrated, and has given accurate drawings to support his opinion.* He says, (page 24,) "the structure of these tusks, and consequently of ivory in general, is layer upon layer, or coat upon coat, like the skins in an onion, or rather the annual circles or rings in trunks of trees." The outer lamella according to my observations is longest, the internal lamellae become shorter and shorter, and the last formed is shortest.

Concerning the teeth of the rhinoceros I have been incorrect, I have mentioned in my thesis (and introduced the remark into the present essay) that I observed the *crusta petrosa* on its teeth: this was from recollection, three years intervening since I saw one in London which was stuffed, and could not meet with one of their teeth in Edinburgh. They are, as Mr. Home mentions, (page 19,) composed only of two substances, scil. bone and the *cortex striatus*.

Mr. Home has not described the structure of the cow's grinder as accurately as the ingenious Mr. Clift drew it, he has represented the tooth as it really is, in general composed of four different substances, tab. xx, fig. 2,) the internal cavities filled with adventitious matter are drawn black, the bony part of a lighter color, the windings of the *cortex striatus* are easily distinguished, and the *crusta petrosa* on the external sides of the tooth is represented white. Mr. Home observes, that a cow's tooth consists of but three substances, and that the internal cavities are filled by the *crusta petrosa*, or what he calls bone. This is an egregious error, and in one interview I had with him in London I could not persuade him to the contrary, although he told me he had seen my thesis and observations on this subject. A similar and greater mistake he has committed with respect to the grinders of the sheep, for their interstices are likewise drawn by Mr. Clift, black, as they really are, (tab. xx,

* Philosophical Transactions, abridged, vol. vi, part iii, p. 24, plate iii.

fig. 3,) being constantly filled with particles of grass, clay, &c. Yet, Mr. Home says, they are filled by the crusta petrosa, and adds, there is none of it on the outside of the tooth. Mr. Home did not understand that in young animals it easily chips off as I formerly mentioned, which was most probably the case in the specimen he examined, and as sheep are commonly killed early in life, and also cows, the quantity of the crusta petrosa on their teeth cannot be in proportion to that on an old horse's tooth, with which Mr. Home compares them. And in the horse's tooth where part of the cavity had been filled with the particles of food, &c. Mr. Home observes in explanation of tab. xx, fig. 1, "the two holes were probably to give passage to arteries, and were enlarged by the food falling into them, *and wearing away their sides.*" These are original remarks indeed.

I shall now take the liberty of referring the right honorable, and honorable, the members of the Royal Society to my thesis, which (by their letter of thanks, dated London, May 9, 1799, and signed by their secretary, E. W. Gray, esq.) they received from me. And with the testimony of Dr. Monro, Sen., in support of my priority of claim, I shall conclude this subject.

SIR:—In November last I received a letter from you, dated Dublin, October 25, 1800, in which you asked me to mention what you showed me in October, 1798, relating to the structure of the teeth in the elephant. In answer to this, I can have no hesitation in declaring,

That in autumn 1798, one of the molares of an elephant, which had been for a considerable time in my possession, was, at your request, sawed perpendicularly; that a drawing and engraving of this, of its full size were executed by your direction; that in October, 1798, you gave me a proof this table, which I preserved and which is now before me. On one corner of it I find engraved, *drawn by William Alston*, and on the other corner *engraved by R. Scott*, and under it *published as the act directs, 1798, by R. Blake, M. D.* You had painted those parts of the tooth, which are outside the plates of enamel of a

yellow color; and you had written on the margin, below the table, *The yellow parts represent the crusta petrosa.* R. B.

One half of the tooth is still in my possession, and, with it, a thin section from the same tooth, in which I have made the distinctions of *enamel*, *osseous substance*, and what you called *crusta petrosa*, more evident, by having exposed it to heat.

I am, sir, your most obedient servant,

ALEXANDER MUNRO, SEN.

Edinburgh, Jan. 25, 1801.

For Dr. BLAKE.

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